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FACILITATING THE ACQUISITION OF MISSION PLANNING AND DYNAMIC REPLANNING EXPERTISE

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14. ABSTRACT

Two current trends–increasingly complex tactical teams and the growing demand for dynamic replanning–have significant implications for mission planning and the ways in which it can best contribute to mission success. Effective mission planning can facilitate team coordination both during the relatively predictable phases of a mission and during more challenging mission events that require dynamic replanning or decision making. However, it is hypothesized that aspects of mission planning expertise that facilitate team coordination during dynamic replanning and decision making are not exactly the same as those that support team coordination during more predictable mission phases. On the basis of this assumption, we proposed to develop the Cognition-Centered Constructivistic Program of Instruction (C3PI) as a means of facilitating the acquisition of those aspects of mission planning expertise that contribute specifically to the ability of a team to respond to dynamic, on-the-fly types of mission events. This Phase I effort involved research and development conducted for the purpose of developing a C3PI system design that is grounded in theory and research and consistent with the training needs and constraints of the operational user community.

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PREFACE

This research was conducted under the Small Business Innovation Research (SBIR) program as a Phase I effort by CHI Systems Inc. for the Air Force Research Laboratory, Human Effectiveness Directorate, Warfighter Training Research Division (AFRL/HEA) under USAF Contract No. F33615-02-M-6010, and Work Unit 3005-HA-2H, Cognitive Demands on Warfighter Readiness. The Laboratory Contract Monitor was Dr Robert T. Nullmeyer, AFRL/HEAS.

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FACILITATING THE ACQUISITION OF MISSION PLANNING AND DYNAMIC REPLANNING EXPERTISE

EXECUTIVE SUMMARY

Two current trends – increasingly complex tactical teams and the growing demand for dynamic replanning – have significant implications for mission planning and the ways in which it can best contribute to mission success. Effective mission planning can facilitate team coordination both during the relatively predictable phases of a mission and during more challenging mission events that require dynamic replanning or decision making. However, it is hypothesized that the aspects of mission planning expertise that facilitate team coordination during dynamic replanning and decision making are not exactly the same as those that support team coordination during the more predictable mission phases. On the basis of this assumption, we proposed to develop the Cognition-Centered Constructivistic Program of Instruction (C3PI) as a means of facilitating the acquisition of those aspects of mission planning expertise that contribute specifically to the ability of a team to respond to dynamic, on-the-fly types of mission events. This Phase I effort involved research and development conducted for the purpose of developing a C3PI system design that is grounded in theory and research and consistent with the training needs and constraints of the operational user community.

The results of the Phase I effort are described in this report. These include (a) a summary of the planning and replanning expertise literature; (b) a summary of training strategies identified as relevant to domains such as air combat in which team adaptability is critical; (c) a description of the C3PI conceptual design; (d) a description of Phase I data collection and analysis; (e) a description of hypotheses about the cognitive elements of expertise; and (f) a description of cognitive task analysis (CTA)-based research plan for investigating these hypotheses during Phase II.

The Phase I work described in this report laid the groundwork for our Phase II effort, which will involve conducting CTA-based research to investigate the cognitive elements of planning expertise, refining and adding to the C3PI design and content based on the findings of that research, implementing the design, and evaluating the value of the system, both in terms of perceived value by the user and more objective measures of performance and expertise enhancement.

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INTRODUCTION

The U.S. Air Force Research Laboratory's Distributed Mission Training (DMT) system has proven its effectiveness in providing high-fidelity training to a variety of military teams. However, if it is to truly support the creed upon which it was founded – that warfighters should train the way they intend to fight – DMT must grow in certain important ways. One of these ways is to include the mission planning phase in DMT exercises. Currently, the mission plan is handed to crews when they arrive for DMT exercises and mission preparation consists mainly of preparing and delivering a mission brief (R. Nullmeyer, personal communication, June 20, 2001). Yet the notion that the quality of mission planning influences whether a mission is executed smoothly is deeply entrenched in military philosophy. Further, the 'Top Gun' of the U.S. Air Force – the Fighter Weapons School (FWS) – cites mission briefs, thereby implicating mission planning, as one of the primary deficiencies demonstrated by entering pilots (R. Nullmeyer, personal communication, June 20, 2001).

Although the mission planning process and plan serve numerous important purposes, one of the potentially most important purposes is to prepare teams for making and executing decisions in a dynamic environment. Warfighters operate in complex, ill-structured, and time-pressured environments, requiring adaptive performance for successful mission execution. Adaptive performance underlies success in many military missions and it can be argued that requirements for adaptability are increasing. In particular, quick and effective responses are critical in today's threat environment, in which the threat of cold war has been replaced by multiple, often unpredictable, asymmetric threats. Further, opponent tactics are harder to anticipate because of the lack of well-defined templates for modern adversaries (Rosenberger, 1995). Technological advances in military systems are increasing the capabilities as well as increasing the information that must be comprehended. Increasingly, too, military teams are distributed, joint, and multinational, requiring integration of platforms, terminology, procedures, and tactics.

Planning can contribute to adaptive performance during mission execution, but neither training nor guidance is rarely provided to help planners better prepare for this particularly challenging aspect of mission execution. Klein and Miller (1999) suggest that planning leads to, among other things, the generation of expectancies, the identification of inconsistencies and planning shortfalls during the planning process; better improvisation during execution; and the development of a shared understanding among team members, allowing them to direct and coordinate their actions. Recent research suggests that mission performance benefits from effective planning. Stout and colleagues (Stout, 1995; Stout, Cannon-Bowers, Salas, & Milanovich, 1999) found that undergraduate teams judged as planning well used more efficient communication strategies under high workload periods and exhibited better coordination during task performance. Spiker, Nullmeyer, Tourville, and Silverman (1997) found a significant

correlation between planning behavior and mission execution for Special Operation Forces during a simulated mission. Mission planning behaviors related to successful mission execution included knowledge of threat capabilities, questioning assumptions, and extensive "what-iffing." An analysis of critical incidents obtained through observations of Navy air wing teams during distributed team training found that contingency planning and "what iffing" were crucial performance issues (Bergondy, Fowlkes, Gualtieri, & Salas, 1998).

To facilitate development of such planning skills, we proposed to design a planning training system called the Cognition-Centered Constructivistic Program of Instruction (CP3I) that facilitates the acquisition of mission planning and dynamic replanning expertise within the context of DMT exercises. DMT offers an ideal environment for training adaptive performance and, similarly, for building planning expertise that supports adaptive performance. The importance of distributed simulation systems such as DMT as a means to train adaptive performance was noted by Colegrove and Alliger (2001, p. 8):

> "The ability to control the training environment provides the opportunity to develop individual and team characteristics such as adaptability, anticipation, and automaticity to a much greater extent than can reliably and consistently be attained in flight. These characteristics lead to increased levels of performance and mission success."

To design this system and lay the groundwork for the research and development we will need to accomplish in Phase II, we performed the following tasks during this Phase I effort:

- Conduct of a literature review of planning and replanning expertise and training
- Review of training strategies relevant to air combat mission planning and to the air combat domain in general
- Development of a preliminary design concept for the Cognition-Centered Constructivistic Program of Instruction (C3PI) training system
- Conduct of cognitive task analysis (CTA) interviews
- Development of hypotheses about the cognitive elements of planning expertise that contribute most to dynamic replanning effectiveness
- Development of a CTA plan for studying the cognitive elements of planning expertise during Phase II

In the sections that follow, we describe the results of these tasks in turn and conclude with a discussion of the research and development to be conducted during Phase II.

PHASE I RESULTS

THE ROLE OF PLANNING IN TEAM ADAPTABILITY

Studies assessing planning and replanning strategies in tactical teams have identified a number of important skills, strategies, and behaviors. In our review of the literature on planning and replanning (also referred to as dynamic and on-the-fly decision making), we were particularly interested in planning skills, strategies, and behaviors associated with effective on-the-fly replanning and decision making during mission execution. In their research on team adaptability in army units, Klein and Pierce (2001) identified a number of team skills and abilities that affect a team's ability to react effectively to unanticipated challenges encountered during mission execution. These 'keys to success' include:

- anticipating problem areas;
- adopting a proactive problem detection mindset;
- preparing for modifying a planned course of action during mission execution;
- having experience with solving problems as a team;
- having the big picture so that local/immediate goals don't overtake the team's objectives;
- developing a repertoire of problem solving routines; and
- having a good sense of the situation, including its affordances (i.e., features that can be used to one's advantage).

Although it can be argued that each of these keys to success may be achieved or brought about through effective planning, Klein and Pierce do not directly link them with planning. Rather, they characterize them as adaptation skills and abilities, asserting "We see team adaptation as more than just being prepared... (p. 7)." In fact, these skills and abilities may represent elements of expertise that both directly and indirectly contribute to team effectiveness across mission phases and activities (e.g., across planning, replanning, and team coordination activities). They may be critical to effective planning – specifically, an effective plan may be one in which mechanisms are built in to facilitate these skills and abilities during mission execution. Along the same lines, planning is likely critical to the effective use of these skills and abilities during mission execution – that is, their effective use would depend upon the foundation of a solid mission plan. Mission planning additionally represents an opportunity to acquire expertise in these areas of skill and ability. Specifically, deliberate planning that involves discussion of these skills and abilities and how to develop a plan that best supports them can be used as an opportunity for more experienced team members to help less experienced members focus on and acquire these skills and abilities. Hence, the mission preparation process is both critical to the effective use of these skills and abilities and relevant to their acquisition.

Klein and Pierce (2001) additionally suggest types of training that can be used to build team adaptability and avoid team 'breakdown points'. As in the case of the above skills and abilities, these training objectives suggest ways mission preparation

can contribute to team adaptability – both as a training opportunity and for the purpose of developing specific types of information in advance. These training objectives include:

- ? develop a large repertoire of problem solving routines;
- ? develop repertoire of self-organizing mechanisms (e.g., timelines & flow snapshots);
- ? train for anomalies, workarounds, and replanning;
- ? develop a proactive "adaptation mindset", e.g., by including at least one malfunction or breakdown in each training exercise/scenario;
- ? calibrate *common ground;*
- ? train for both external and internal adaptation;
- ? train to manage more degrees of freedom;
- ? train communication workarounds;
- ? train information seeking skills;
- ? train to rapidly "parse" a task (so parts of task can be reallocated); and
- ? train to appreciate the team's affordances/resources and how they can be combined in different ways.

Many of Klein and Pierce's recommendations, although based on work with army units, are relevant to other types of tactical teams, including air combat teams. Other examples of critical elements of expertise that contribute to team adaptability were identified by Klein and Miller (1999), who suggest that adaptive teams generate expectancies and identify inconsistencies and planning shortfalls during the planning process. Other researchers have examined mission planning to identify planning skills and strategies that contribute to the adaptability of tactical teams during mission execution. Identified skills and strategies include developing contingency plans (e.g., Bergondy, Fowlkes, Gualtieri, & Salas, 1998), developing *thorough* contingency plans (e.g., Macmillan, Entin, & Serfaty, 1993), identifying problem areas (e.g., Crane, 1999), questioning assumptions (e.g., Bergondy et al., 1998; MacMillan et al., 1993; Spiker, Nullmeyer, Tourville, & Silverman, 1997; Spiker, Nullmeyer, & Tourville, 2001), describing and rehearsing situation-specific radio calls (e.g., Nullmeyer, Crane, Cicero, & Spiker, 2000), and using a what-iffing strategy to evaluate the plan (e.g., Bergondy et al., 1998; Crane, 1999; Spiker et al., 1997, 2001).

Effective planning appears to facilitate team adaptability by allowing team members to anticipate the information needs of their teammates and provide that information without being requested to do so (e.g., Orasanu, 1990; Stout et al., 1999). This anticipatory and proactive communication strategy is especially important when communications are constrained, as in large and complex teams (e.g., Gualtieri, Bergondy, Oser, & Fowlkes, 1998) and in high workload situations (e.g., Orasanu, 1990; Stout, et al., 1999).

Effective planning, both prior to and during mission execution (i.e., dynamic replanning), is hypothesized to facilitate team adaptability by helping team members develop *shared mental models* or *common ground* that provide them with an understanding of teammates' expectations, responsibilities, and informational requirements (e.g., Klein & Miller, 1999; Stout, 1995; Stout, Cannon-Bowers, Salas, & Milanovich, 1999). Bergondy, Fowlkes, Gualtieri, and Salas (1998) assert that, during the mission brief, it is critical that naval air wing tactical team members develop compatible mental models of the mission, and that in the execution phase it is critical for them to update these models and use them to identify deviations from the plan and guide interactions with other team members. While direct evidence is lacking (possibly due to the difficulty associated with measuring mental models), this hypothesis is supported by research showing that teamwork and/or interpositional knowledge training enhances task performance (e.g., Cooke et al., 2000). Shared mental models are thought to be the means by which planning helps team members use proactive communication strategies (e.g., Stout & Salas, 1993). In addition, it has been suggested that shared mental models allow teams to use implicit coordination strategies (e.g., Gualtieri, et al., 1998; Entin & Serfaty, 1999). That is, team members are thought to act and make decisions based on these shared models in order to maintain performance levels when high workload conditions inhibit overt communication.

Thus, a substantial number of factors related to successful team adaptability in a dynamic environment have been identified. Importantly, many of these factors are linked to the mission preparation phase and planning, in particular. These include anticipation, proactivity, problem detection, preparation for change, problem solving strategies, consideration of the big picture and long term goals, situational knowledge, strategies for building common ground, and planning strategies such as contingency planning, what-iffing, assumption questioning, identification of inconsistencies and problem areas, and rehearsal.

TRAINING STRATEGIES THAT ENHANCE TEAM ADAPTABILITY

Recommendations Based on Research and Theory

The emphasis of this Phase I effort was not just on how teams effectively prepare for dynamic task performance environments, but also on how to best train teams to effectively prepare for them. Accordingly, we reviewed training research and theory relevant to building adaptability in teams. Certain training strategies and guidelines described in this literature were identified as particularly relevant to our training objectives and to the air combat mission planning domain. These relevant strategies and guidelines are summarized here:

- *Adaptability is enhanced by active processing*. Adaptive performance requires an active, critically thinking human. Klein, Pliske, Crandall, and Woods (1999) performed an analysis of critical incidents across domains that included firefighting, US Army planners, and nurses in intensive care units. Their results suggest that problem detection is an active process and that operators must be

prepared to discover anomalies. This principle is borne out of a number of research domains.

- Based on observations of Stability and Support Operations, Klein and Pierce (2001) argue that it is important that warfighters develop a proactive mindset and be prepared to recognize situational cue patterns that should promote adaptive behavior.
- Pierce and Pomranky (2001), working with similar military teams, developed an Adaptive Learning Model to drive a training system concept. Guidance from this model suggests the importance of immersing learners in context- relevant simulations and exposing them to realistic problems.
- The Adaptive Learning Model is based in part on the theory of cognitive flexibility, an educational approach that has been used to drive advanced education in domains such as medicine. "Cognitive flexibility," or effective problem solving in ill-structured domains, can be facilitated by advanced instructional strategies that require learners to use the same knowledge elements, but from different perspectives, prompted, for example, by the presentations of problems and case studies (Spiro, Feltovich, Jacobson, & Coulson, 1992).
- Learner-generated solutions and discovery learning lead to better transfer to novel situations (Smith, Ford, & Kozlowski, 1997).
- Mental simulation is another training strategy that encourages active processing. Cohen, Thompson, Adelman, Bresnick, Tolcott & Freeman (1995) stress critical thinking and deliberate mental simulation in the recognition-meta-recognition model. According to this model, once a situation is recognized, it can be subjected to a number of tests, similar to the way good readers develop and actively test hypotheses about their comprehension. Kozlowski (1998) recommends mental rehearsal as a training intervention that encourages trainees to think through contingencies.

? *Adaptability should be trained in context.* Research suggests that the development of adaptive performance requires "domain-specific" practice (Pierce & Pomranky, 2001). Kozlowski (1998, p.116) noted:

> "Whereas basic skills can be developed in conventional training environments (i.e., the classroom), adaptive skills are fully developed and refined in the performance environment. This means shifting more training to the performance context and developing new training strategies and techniques that can be integrated into the work environment."

? *Adaptability is enhanced by the development of links between key knowledge elements in the domain.* Training strategies to improve adaptive performance provide context specific learning prompts to understand the complex interrelationships among domain features (Kozlowski, 1998; Pierce & Pomranky, 2001; Spiro et al., 1992).

? *Team adaptability is supported by shared mental models.* Researchers have argued that team adaptability is supported by team members who have consistent expectations for how environmental factors should guide actions. For example, in military teams, it is crucial for teams to have a common understanding of how factors such as commander's intent and the enemy order of battle should influence decisions and actions.

Research on both planning and training for dynamic environments is consistent with the use of a *what-iffing* type of strategy to build team adaptability. In addition to being associated with effective planning (as described in the preceding section), this type of strategy is recommended by Klein and Pierce (2001) as a means for building adaptive teams and is represented in the Adaptive Battlefield Thinking program in the form of *disequilibrium experiences (i.e.,* events of a difficulty level with which trainees have not yet gained experience and which causes them to question and re-evaluate their assumptions and strategies; Ross & Pierce, 2000). Further, the strategy is already used extensively in training by various operational military communities, as discussed below.

Lessons from Military Operational Communities

Although planning for uncertain environments and dynamic replanning within those environments has received heightened attention in the past decade (e.g., due to the high priority of time critical targets), they have been pervasive aspects of tactical mission performance throughout history. Accordingly, the military services and branches have evolved planning and training techniques that, although not officially recognized for it, prepare personnel for planning and replanning in dynamic environments. These techniques include strategies that help build team common ground and shared mental models (e.g., the shared use of planning maps and planning whiteboards, and sand tables around which multiple team elements can gather) and strategies that help foster proactive thinking, assumption questioning, and contingency preparation during planning.

This latter type of strategy typically takes the form of what-iffing. For example, in U.S Marine Corp Combined Arms Staff Trainer (CAST) exercises, expert CAST exercise controllers look for weaknesses in trainee plans and then insert what-if challenges into sand table exercises to target those weaknesses. As another example, during integrated naval air wing training held at the Naval Strike and Air Warfare Center (NSAWC), instructors sit in on briefing sessions in order to identify weaknesses in the briefed plan. Subsequently, they may introduce challenges into the training mission (e.g., a pop-up surface-to-air missile [SAM] or a threat in the target area) that are designed to exploit those weaknesses. Thus, they what-if the plan during the execution of the mission – an effective way of demonstrating to trainees the importance of proactive thinking, assumption questioning, and contingency planning during the planning phase. Air force fighter pilots use a what-iffing strategy, as well. Similar to the naval air wing example, one of the fighter pilots designated to play the adversary role during a given training mission may listen to the training team's mission brief of the in

order to identify the weaknesses in their plan. The adversarial pilot then joins with the rest of the adversarial team to develop a plan that will exploit those weaknesses. Again, the technique features what-iffing during mission execution instead of during planning, but it nonetheless is an effective way of driving home the benefit to be gained by what-iffing prior to mission execution.

In these examples, what-iffing takes place during the mission execution or, in the case of CAST exercises, during the simulation phase of training exercises rather than during the mission preparation phase. This approach treats mission execution and simulation that takes place in the context of training as a form of real world mission preparation. That is, rather than being limited to what-iffing in a planning room using only a whiteboard, markers, and the team's cognitive resources, what-iffing is conducted in the hands-on environment of a high-fidelity simulation or live training mission. The benefits of this approach include the opportunity to practice responding to dynamic replanning and decision events under more realistic conditions. The approach additionally can benefit mission preparation and possibly improve the use of what-iffing during the planning phase of real world missions. Specifically, the insertion of what-if events during mission execution or simulation serves to make trainees aware of both the weaknesses in their plan and (sometimes painfully aware) of the consequences of those weaknesses. In addition, what-if training strategies enrich trainees' knowledge base through exposure to realistic what-if experiences. These what-if events thus become sources of experience that a trainee may subsequently draw upon to what-if during real-world missions.

What-iffing is also used in air combat mission planning rooms, although the extent to which it is used and its quality varies considerably depending on, for example, the team lead, mission type, and planning constraints. Thus, what-iffing is a technique that is already viewed as effective by combat mission planning teams. Because of its acceptance and because research suggests that it plays an important role in team adaptability and mission preparedness, what-iffing was adopted as the training strategy around which the C3PI system was developed. C3PI will encourage what-iffing during mission planning both via its training mechanisms and by making the process more stimulating through the provision of a variety of events, challenges, and tools. It will additionally support trainees, instructors, and planners by making available a wide range of challenging what-if possibilities. Thus, C3PI is designed to provide some of the same training benefits associated with what-iffing during mission execution. Although this training will not necessarily make trainees aware of the potential consequences of insufficient planning in the way the techniques described above do (as a marine has described it, "they will learn if they bleed"), it will include a number of tools that help the planner think through the plan elements in a comprehensive way and consider various potential consequences. Furthermore, it will expose trainees to a potentially large number of what-if events and what-if challenges associated with different levels of difficulty, thereby building their 'what-if' knowledge base.

C3PI offers training benefits in addition to those provided by what-iffing. These additional benefits stem from the fact that although C3PI is designed to support the

conduct of what-iffing exercises, the exercises are, in fact, used as a 'training delivery vehicle or mechanism. What-iffing is a valuable experientially-based training technique that is accepted by the operational community. As such, what-iffing exercises represent an effective means for implementing and integrating a number of other training techniques aimed at building expertise in planning.

Although the C3PI tools and features are described in detail below, a few are briefly introduced here to demonstrate how the what-iffing paradigm can be used to integrate multiple training strategies and objectives. For example, the C3PI design specifies planning tools that give trainees access to lessons learned and video clips of experts relating advice. These tools represent a form of analogy- or case-based learning, as noted previously. The *Platform Specs* tool represents a form of cross training and a means of building critical types of knowledge – knowledge about team members and knowledge about enemy capabilities. Another training objective of C3PI is to help trainees build the knowledge and knowledge structures that support effective what-if planning. C3PI is designed to meet this objective using a scaffolding, event-based training approach and a form of attentional advice (i.e., *knowledge-use prompts;* e.g., Cannon-Bowers, Rhodenizer, Salas, & Bowers, 1998). It is anticipated that proposed Phase II research will reveal additional aspects of planning expertise and that training strategies designed to target those aspects will be integrated into the C3PI what-iffing framework.

C3PI additionally will make evident to trainees the linkages between mission planning and execution, and it will do this using an event-based training type of approach (e.g., Fowlkes et al., 1998). Links will be emphasized by exposing DMT teams to what-if events during DMT mission execution, including some events that were previously what-iffed using C3PI and others that were not, and then by asking the teams to discuss during the After Action Review (AAR) the ways in which the what-iffing they performed prior to mission execution was helpful and in what ways it could have been better. As part of the C3PI Phase II effort, we will perform research to, among other things, identify performance measures that are affected by what-iffing effectiveness during mission preparation. These measures will also be used to demonstrate this link to trainees.

DEVELOPMENT OF A PRELIMINARY CONCEPT DESIGN

In this section, we describe the Phase I conceptual C3PI design. First we give an overview of the rationale for the what-iffing framework used as the core of the design. Then the conceptual design is described – first, in terms of a concept of operations for how a user would interact with the system and then a description of systems specifications and requirements. This section is followed by a section that describes research conducted in association with this effort, and a description of future work to conclude the report.

Influences

Increasingly complex tactical teams and the growing demand for dynamic replanning – have significant implications for mission planning and the ways in which it can best contribute to mission success. Effective mission planning can facilitate team coordination both during the relatively predictable phases of a mission and during more challenging mission events that require dynamic replanning or decision making. However, it is hypothesized that the aspects of mission planning expertise that facilitate team coordination during dynamic replanning and decision making are not exactly the same as those that support team coordination during the more predictable mission phases. On the basis of this assumption, we proposed to develop C3PI as a means of facilitating the acquisition of those aspects of mission planning expertise that contribute specifically to the ability of a team to respond to dynamic, on-the-fly types of mission events.

The C3PI conceptual design represents a planning and training system that is based on what-if exercises. As discussed above, what-iffing is an experientially-based training technique that is accepted by the operational community and has been found by researchers to contribute to mission success and team adaptability. Its use is consistent with the training guidelines described above, as what-iffing enhances active processing and critical thinking skills and provides context-specific opportunities for mental simulation and for building relevant domain knowledge. Further, what-iffing serves as a rich context for introducing a number of other training techniques aimed at building expertise in planning. Thus, what-iffing additionally is used within C3PI as a vehicle for applying multiple complementary training strategies in an integrated way to help trainees acquire expert planning skills, strategies, and knowledge to improve on-the-fly decision making and dynamic replanning.

C3PI is based on a training philosophy similar to event-based training in which the mission briefing, execution, and debriefing phases represent opportunities to extend the training benefits associated with using C3PI during the planning phase (e.g., Fowlkes, Dwyer, Oser, & Salas, 1998). Accordingly, C3PI will integrate with briefing, performance assessment, and AAR technologies and phases. The C3PI application initially will be developed to support DMT training exercises (although it may also be used independently of them) and is being developed for collaborative use across distributed sites.

C3PI Concept of Operations

During Phase I, a conceptual C3PI design was developed based on research literature, subject-matter expert (SME) interviews, and procedures followed by the operational community, as described above. In this section, we describe a C3PI training session in terms of how a new user would interact with the system. Figure 1 depicts a sequence of high-level interactions associated with this training session. The description below assumes that the user participated in the initial baseline DMT scenario and now wants to use C3PI as part of preparing for the first training scenario.

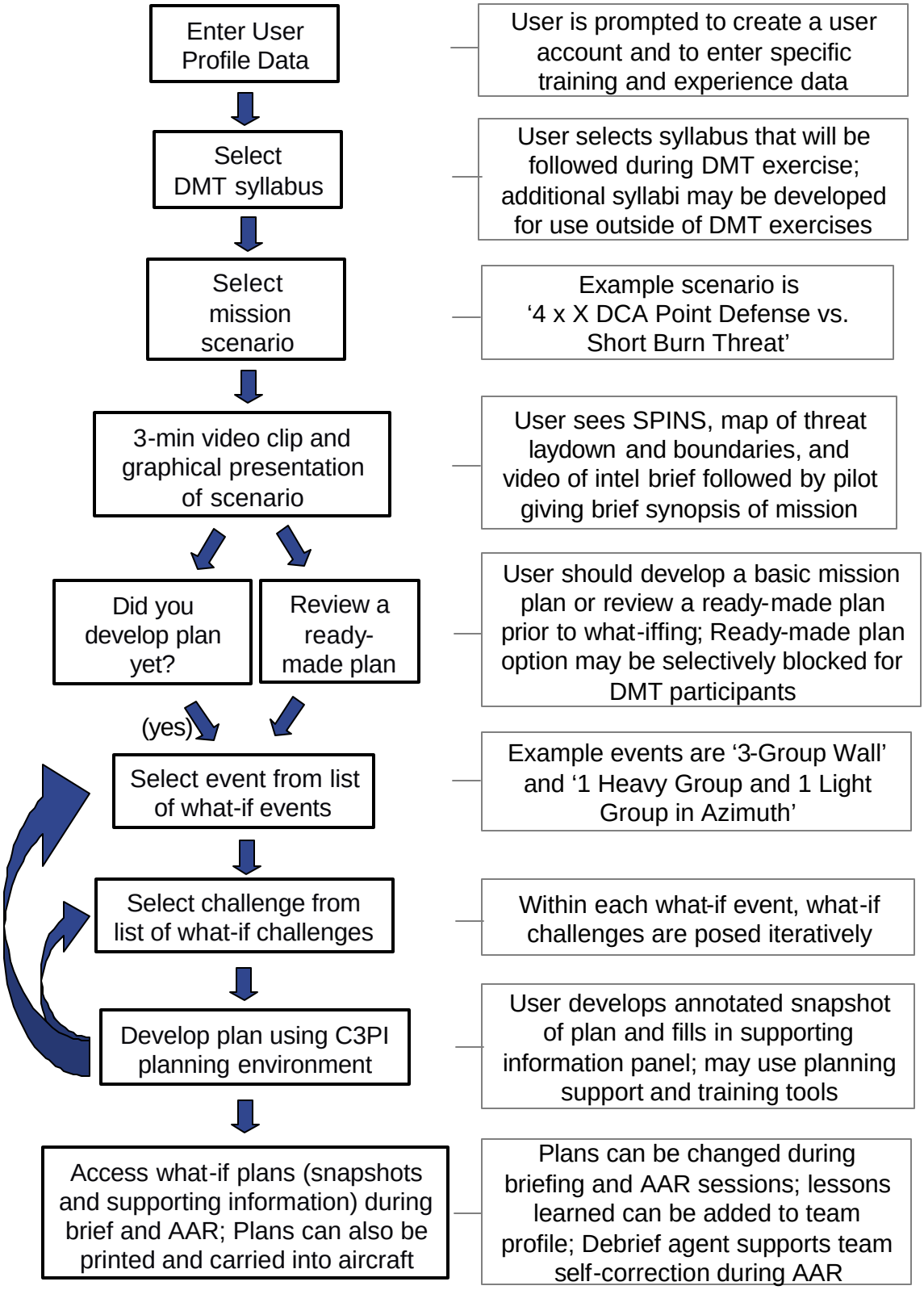

***Figure 1*. User interactions with C3PI during what-if planning exercises.**

Entering a user profile. After the user initiates the C3PI session, he will be asked to create a user account and to provide information that will become part of his user profile. He will be prompted to identify his DMT team so that he can access shared team-level information including DMT team performance metrics and lessons learned accumulated by the team across the week of exercises. In addition, he will be prompted to enter training and experience data so the system can approximate his level of expertise. C3PI will automatically track each user's progress within C3PI with respect to syllabi and scenarios practiced and with respect to experience with different event types and knowledge categories.

Selecting a syllabus and scenario. After initiating an account and entering user profile data (or after logging on if it is not the user's first session), the user will be prompted to choose a DMT syllabus (he will be asked to choose the one he is following during that particular week-long exercise) and then a scenario from the syllabus. The user will be encouraged (e.g., using automated feedback) to choose the first scenario that has not previously been chosen (scenarios are ordered according to approximate difficulty). After the scenario has been chosen, a scenario or mission synopsis is presented to the user. This synopsis consists of a text presentation of the basic mission parameters, including special instructions (SPINS), a graphical depiction of boundaries and the enemy order of battle, and a brief video clip presentation featuring an intel officer and then a pilot briefing the threat situation and the scenario objectives, respectively.

In case the user has not already developed a basic mission plan for this particular scenario, C3PI will prompt them to do so following the scenario synopsis. Alternatively, if the user is only using the system to practice what-iffing, he will be able to request a brief of a ready-made mission plan for the scenario, which will be presented via a combination of video clip and text-based briefing charts. The ready-made plan option may be selectively blocked so that DMT participants will be forced to develop their own mission plan.

Selecting what-if events. After the scenario synopsis is presented, the user is given access to a list of *what-if events*. What-if events will be situations that might occur within a scenario. They will largely consist of various threat presentations but will additionally include other types of challenges that require on-the-fly replanning or decision making, such as being directed to cover a neighboring lane during a defensive counter air (DCA) lane defense mission, finding out that a member of your 4-ship has no radar capabilities, or losing Airborne Warning and Control System (AWACS) support. What-if events will be stored in a relational database and will be assigned attributes including approximate difficulty level and category/ies of mission knowledge emphasized. Additional attributes may be assigned if Phase II research identifies additional elements of expertise that event presentations should be structured to target. The list of what-if events presented to the user will be randomly selected without replacement from a subset of what-if events that are consistent with the approximate level of expertise suggested by his user profile and progress through the DMT syllabus. Because this particular user is relatively inexperienced and is preparing for his first DMT

mission, the list of events he is shown will be relatively easy events that emphasize the use of more basic types of mission knowledge, such as knowledge required to establish decision criteria and knowledge required to establish timing and flow.

Selecting what-if challenges. The user may develop a plan for a given what-if event and then return to the list of events to choose another. Alternatively, the user may choose to be given one or more *what-if challenges* after choosing a what-if event. What-if challenges are situations that might occur within the context of the what-if event as it unfolds. As an example, a user who selected the what-if event '3-Group Wall' might be given what-if challenges such as those in the following list:

- Southern bandit drags south
- Southern bandit turns back in but Viper 03 previously broke lock
- Viper 03 detects Southern bandit hot
- Viper 03 can't get clear channel to communicate change in bandit's bearing and aspect
- Viper 03 decides to engage without communicating decision
- Viper 03 exits merge and wants to find Viper 04
- Viper 03 trying to find 04, flies too close to engagement and gets a buddy spike
- Viper 04 targeting northern group instead of middle
- Viper 02 isn't making targeting call when you expect to hear it
- Vipers exit merge
- Viper 02 flies in too far and gets mud spike
- Cold Ops: There are four remaining bandits and Viper 02 and 04 are low on fuel
- Cold Ops: Jamming interferes with AWACS communications
- Cold Ops: Viper 02 reports bingo

What-if challenges will be stored in a database and will be assigned attributes including what-if events for which they are appropriate, event phase with which they are associated, approximate level of difficulty, and category/ies of mission knowledge emphasized. A new what-if challenge will be presented to the user each time he clicks on the 'New What-If Challenge' button. Challenges tend to be associated with event phases and so will be presented in a serial order that is consistent with progression through those phases. Each challenge presented will have been randomly selected without replacement from a subset of what-if challenges that are matched to the current what-if event, event phase, approximate level of user expertise, and progress through the DMT syllabus.

The what-if planning environment. Once the user has selected a what-if event, he enters the what-if planning environment. A depiction of the proposed conceptual design of this environment is shown in Figure 2. The environment includes a central *snapshot panel*, a *supporting information panel* to the right of the snapshot panel, a *knowledge categories panel* on the left side of the snapshot panel, and a toolbar across the bottom of the screen. When the user enters this environment, the

snapshot panel will contain symbols (e.g., arrows) showing the headings and positions of hostile, bogey, and friendly aircraft associated with the scenario and the selected what-if event. A summary of the what-if event will be presented as a heading at the top of the screen.

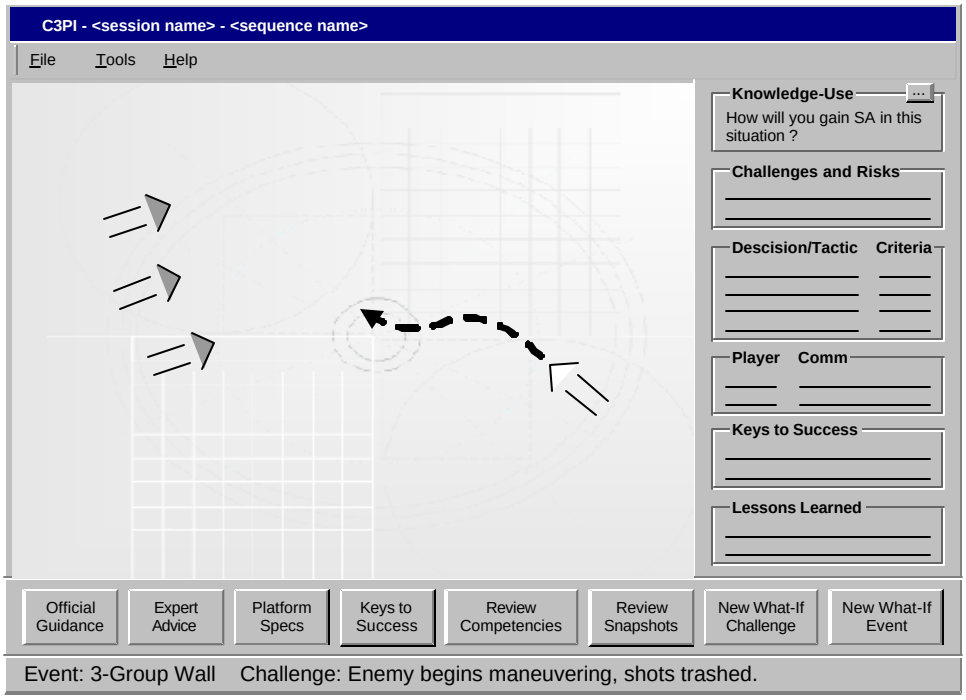

***Figure 2*. Phase I design of the C3PI what-if planning environment.**

Using the planning environment. To develop a plan in response to a given what-if event, the user "pens" to interact with the electronic whiteboard. Specifically, the user can draw and erase colored lines and symbols on the snapshot panel. He can additionally write supporting details, such as ranges and altitudes, on the snapshots. Planning support and training tools can be used to supplement and guide plan development, and by clicking on the Knowledge-Use box, the user will have a set of knowledge categories from which planning prompts, or *knowledge-use prompts*, may be requested.

***Supporting information panel*.** The supporting information panel provides another location for planning information to be recorded. This panel is intended to allow the user to write down, type in, or copy and paste from a previous plan considerations, decisions, and guidance specific to a plan developed for a given what-if event and challenge. The supporting information contained in this panel will be saved together with the associated snapshot if the user decides to save his plan. We propose to determine the exact set of supporting information categories that users may choose to work by conducting additional assessments of user requirements during Phase II. Examples of supporting information categories include the following:

- *Challenges and Risks* – User can list potential problems, challenges, and risks associated with each what-if challenge.
- *Decision/Tactic and Criteria* – User can list decision points and tactics and their associated criteria. Examples of decision points include split points, intercept points, and abort decisions.
- *Player and Comm* – User can list examples of radio calls that should be made by the AWACS, F-16 pilots, and any other event participants, or list comm discipline rules that should be followed (e.g., who has comm priority during the event).
- *Keys to Success* – User can list 'Keys to Success', a set of reminders about the key things that need to be accomplished by the team for the event or mission to be successful.
- *Relevant Lessons Learned* – User can review lessons learned identified by her team during previous missions by clicking on the 'Lessons Learned' button. Of these lessons learned (they can also use other available sources), the user might want to list any that might be relevant to the current event. This might increase the influence of lessons learned on planning and it might be useful information to include in the mission brief.

Knowledge categories and knowledge-use prompts. The user will be encouraged to use the knowledge categories panel to support the what-if planning process (the encouragement mechanism will be determined by working with users during Phase II). These knowledge categories are heavily influenced by types of knowledge members of naval air wing tactical teams were found to use to achieve team coordination in a CTA of naval strike team coordination (Neville et al., 2002). The CTA additionally revealed that certain knowledge categories were used infrequently by less experienced team members. For example, knowledge about other team member's procedures and capabilities and about one's own limitations and constraints tended to not be used by less experienced team members. In addition, although experienced and less experienced team members appeared to be equally knowledgeable about team member support requirements, the less experienced team members were less likely to describe using that knowledge to anticipate and proactively meet support requirements.

Accordingly, C3PI knowledge categories labeled 'limitations' and 'mutual support' are considered more advanced than those for which experience-related differences were not observed, such as 'decision points and criteria' and 'timing and flow'. The C3PI knowledge category 'Initial SA' was added based on Phase I interviews indicating that an important part of planning for what-if situations is determining how the situation will be detected and communicated to the team. Another knowledge category, 'enemy tactics' was added, based on data collected during both the CTA of naval strike team coordination (collected but not part of the analysis) and C3PI Phase I interviews. These data and interviews suggested that knowledge about enemy tactics is associated with expertise, and consequently 'enemy tactics' was added to the C3PI knowledge categories and is considered a more advanced category. The proposed Phase II research will examine whether knowledge about building initial SA and enemy tactics is brought to bear more often or differently by more versus less experienced air combat

team planners. In addition, it will reexamine the other knowledge categories with respect to experience-related differences.

To use these knowledge categories, the user clicks on them, one at a time, to access a list of knowledge-use prompts. The user then selects a knowledge-use prompt for a given category and that prompt appears in a text box inside the knowledge category panel. The prompts, which will be stored in a database, are designed to prompt the user to consider the types of information and use the types of critical thinking strategies an expert what-if planner might use. They represent a form of attentional advice, a training strategy whereby trainees are given guidance about how to focus their attention during a training session (e.g., Cannon-Bowers et al., 1998).

Because evidence suggests that the knowledge categories may differ with respect to how fluently or adeptly they can be used by less experienced members of tactical teams, the knowledge category panel will be designed to guide trainees' use of these categories. Further, in case a user lacks the knowledge to respond effectively to a given knowledge-use prompt, each prompt will be associated with expert advice video clips, portions of official USAF planning doctrine, and any relevant enemy or friendly platform capability specifications. In other words, each prompt will have a direct link to contents of planning and training tools described below.

Each knowledge category will be associated with multiple knowledge-use prompts identified during the Phase I and Phase II research efforts. Example prompts for each category are as follows:

- *Initial SA*
  - How will team build SA about this situation?
  - What needs to be done and said and by whom?
  - How will AWACS describe this configuration over the radio?
- *Decision Points and Criteria*
  - What are the decisions?
  - Who is the decision maker for a given decision (e.g., AWACS or Flight Lead)? Will decision maker need help recognizing that criteria were met?
  - Are the decision criteria consistent with the risk acceptance level?
  - What could team members do or say to prevent the what-if situation from reaching abort (or other negative) criteria?
  - Are there steps you can take to build an adaptive mindset to facilitate the required shift in the plan when criteria are met?
- *Timing and Flow*
  - Who should be where? How should they be flowing?
- *Mutual Support*
  - Who needs support during this situation?
  - How will the support need be recognized?
  - Who will provide the needed support and how?
- *Enemy Tactics*
  - What might the enemy do next in this situation?

- How can you be best positioned to respond?

? *Limitations*
  - What factors might limit your ability to detect or respond to this situation?
  - What can the team do to counter identified limiting factors?

The planning support and training tools. In case the user finds that he lacks the knowledge to answer a given knowledge use prompt, each prompt will be directly linked with relevant C3PI planning and training tools. Thus, for example, if more information about enemy or team member platform (e.g., AWACS) capabilities is needed to respond to the knowledge-use prompt, the user will be able to jump directly from the prompt to the relevant information contained in the Platform Specs tool. Alternatively, if official USAF planning guidance is relevant, a direct link to the Official Guidance tool will be available. Similarly, direct links will be available to take the user to Expert Advice video clips of other pilots describing a planning strategy they use or a mission consequence they experienced that is relevant to the knowledge-use prompt.

Planning support and training tools can be accessed at any time during a planning session. In addition to helping users build knowledge in the C3PI knowledge categories, they can be used as general sources of case-based training (e.g., through expert advice video clips) and cross-training (e.g., through access to platform specs) that may contribute to the acquisition of what-if mission planning expertise. As noted previously, planning support and training tools may be added during Phase II to target additional elements of what-if and contingency planning expertise identified during the remainder of the Phase I research or during the Phase II research. Currently, tools proposed for inclusion in the C3PI planning environment include:

? *Official Guidance*
  - Official planning guidance, e.g., squadron planning guides and Air Force Tactics, Techniques, and Procedures (AFTTP) 3-1

? *Expert Advice*
  - Video clips in which instructor-level pilots describe planning strategies that have worked for them, factors they have learned to consider, etc. (or role-players describe the pilots' advice)
  - Advice taken from CTA interviews and other interview opportunities

? *Platform Specs*
  - Capabilities, limitations, and characteristics of friendly and enemy aircraft

? *Keys to Success*
  - Compilation of keys to success accumulated by a given DMT team during their week of exercises, organized by scenario
  - Might include access to keys to success accumulated by other teams

? *Lessons Learned*
  - Compilation of lessons learned identified during AAR by a given DMT team throughout their week of exercises, organized by DMT scenario
  - Might include access to lessons learned of other teams

? *Review Competencies*

- Allows user to review elements of planning expertise and knowledge categories targeted by a given what-if event or what-if challenge

Using the what-if plans during briefing and AAR. In addition to supporting the mission planning phase, C3PI is designed to facilitate mission briefing and AAR, as shown in Figure 3. For example, after the user has completed a plan for a given what-if event or what-if challenge, she can save it for later use. During the mission brief, these saved plans – each consisting of a *snapshot* and the associated supporting information (from the supporting information panel) – can be printed and distributed to team members and/or displayed using the DMT Collaborative Planning, Briefing, and Debriefing System (e.g., Sidor, 2002), which also utilizes the Smart Technologies interactive whiteboard system. If they are displayed using the DMT Collaborative Planning, Briefing, and Debriefing System, the user will be able to continue to draw on the plans during the briefing sessions and will be able to utilize C3PI planning and training tools. To facilitate tool use in this and the AAR setting, the C3PI will feature a keyword-based tool search option so that the user may quickly identify relevant expert advice, lessons learned, official guidance, etc. to answer plan-related questions that may arise.

C3PI also allows snapshots and supporting information to be printed and distributed to team members during the mission brief. Mission plan snapshots tend to be easy to comprehend and follow, they can help a team develop a shared mental model during mission execution, and they may help team members follow the briefed plan. For these reasons, team members may want to bring the snapshots into their aircraft with them.

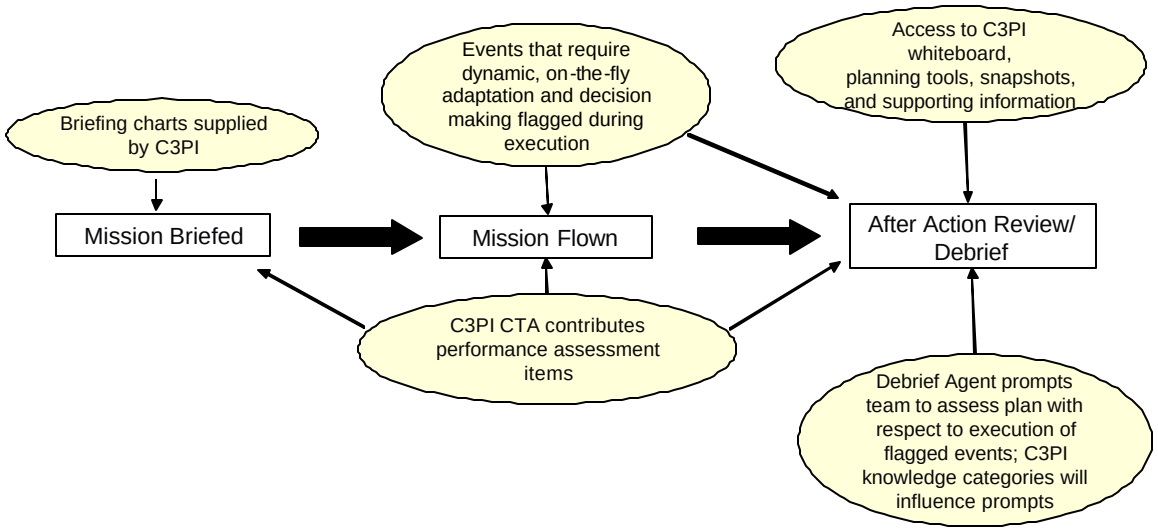

Figure 3. **Description of ways C3PI will contribute to mission briefing and AAR.**

The C3PI what-if plans may be displayed using the same collaborative system during debriefing, or AAR. This will allow a team to view both their DMT mission performance playback and their relevant what-if plans simultaneously. Dynamic replanning and decision making events that occur during mission execution – including both events that map onto what-iffed events and events that were not specifically addressed during what-if planning – could be flagged (e.g., using the AFRL performance evaluation and tracking system [PETS]) during mission execution for subsequent assessment using the C3PI plans and tools). In particular, the C3PI design features a team self-correction training tool – the debrief agent – that prompts the team to evaluate their preparation for and performance during dynamic replanning and decision making events in a constructive and process-oriented way (e.g., Blickensderfer et al., 1997). Teams will additionally be prompted to add any lessons learned to C3PI for use in their future C3PI planning sessions (access to team plans, data, and inputs will be limited to team members and DMT instructors).

C3PI System Specifications

This section describes the C3PI system and application requirements. The C3PI Phase II plan proposes incremental development of the system and application based or iterative reviews and refinements with the user community. The system is described in general terms because it is expected to evolve as Phase II progresses.

Hardware configuration. The C3PI system will be implemented with a custom software application executing on a standard Intel-based Personal Computer. The C3PI system will incorporate a SMART Board™ unit developed by SMART Technologies, Inc. This device emulates a writing surface similar to that of a dry-erase whiteboard by using a coordinate sensing display overlay and a special stylus. An application screen is projected on the SMART Board. Images are drawn with a special 'color' stylus retrieved from several stored in the SMART Pen Tray™. The SMART Pen Tray communicates with the whiteboard emulation application so that the application can duplicate the freehand drawing in the color selected by the user. The integrated stylus may also emulate standard mouse input for the application that is driving the projected display. This allows the user to interact with the application as one would with a desktop application.

The C3PI PC will use a 10/100 Base-T Ethernet Network Interface Card (NIC) as an interface to a LAN or WAN. This hardware will support the Microsoft NetMeeting™ application in providing distributed training capability for C3PI.

Network interoperability. The C3PI system will be capable of remote interoperability using a LAN or WAN connection. The Microsoft NetMeeting™ application will be used to transparently provide this interoperability. Microsoft NetMeeting™ is a powerful teleconferencing and collaboration network application. NetMeeting supports the traditional teleconferencing capabilities such as bi-direction audio and video feeds, chat and whiteboard interactions and file transfers. C3PI benefits from NetMeeting's ability to reproduce a PC display at a remote site and receive

application interactions from users at those remote sites. NetMeeting communicates using TCP/IP so integration with a secure network is trivial since TCP/IP may be wrapped in a secure transport-layer envelope.

SMART Board whiteboard emulation. The SMART Board™ includes utility software to allow capture of the 'whiteboard' drawn images. This utility will be used to capture scenario drawings, save them with the scenario, and later restore the images so that they may overlay the application-generated graphics.

Application context: The data model. The C3PI data model represents a session that is saved as a standard operating-system file. The data-model contains all context necessary to preserve (save) and reconstruct (load) the session. The data model is hierarchical where the topmost 'root' element is the team. A C3PI session is organized with respect to the team members – users. For a particular user, the data model contains a list of sessions for which the user has participated. Each user is also associated with training statistics and history describing overall C3PI participation. The data model will evolve as the C3PI application context progresses through its iterative development cycle. The C3PI data model specifies team profiles, sessions, scenarios, what-if events, what-if challenges and is abstracted as follows:

Team profile. The team profile corresponds to a unique file name. When a C3PI session is initiated, the user will create a new team profile file, or open an existing predefined team profile file. The team profile contains a C3PI historical record for the team and a list of User Profile Identifiers. Each user profile will contain the team member's unique C3PI history, various statistics, and a list of the performed sessions and their respective context:

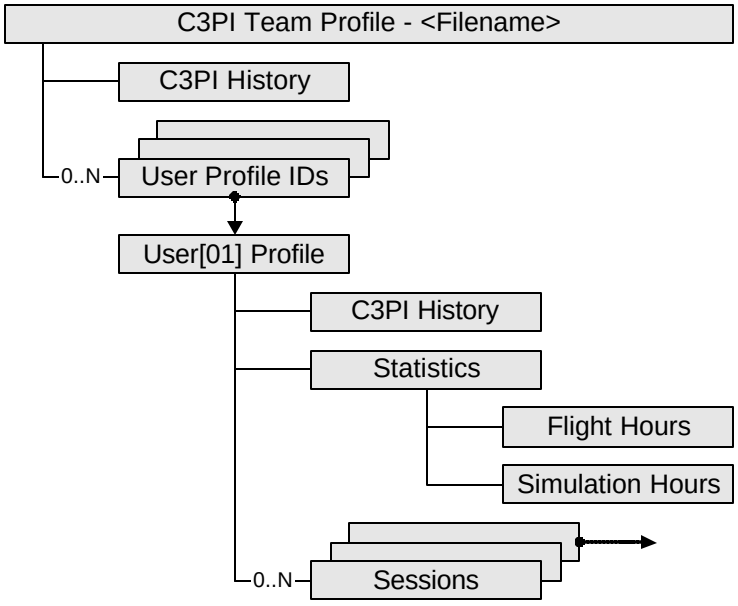

Figure 4. **Team Profile Data Model**

Session. Each session for a given team member will contain a particular syllabus. The syllabus will be comprised of multiple DMT scenarios:

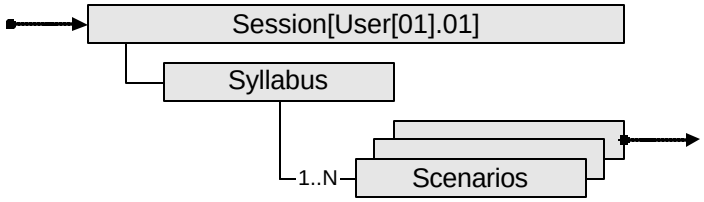

Figure 5. **Session Data Model**

Scenario. Each DMT scenario will contain a link to the team's DMT history and a link to the mission synopsis. These items are represented as links as their context does not vary for each scenario. A list of what-if events and their respective context will be maintained in the scenario unique to the particular user and session.

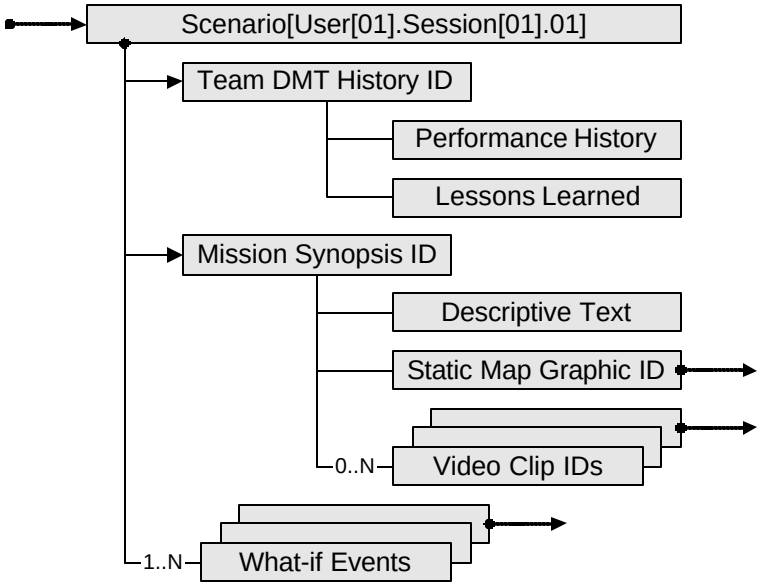

Figure 6**. Scenario Data Model**

What-if Event. Each what-if event will contain a link to its associated whiteboard overlay. This overlay will be created and revised by the user and merged with static or interactive background graphics by the C3PI application and COTS software provided with the SMART Board. Each event will define unique text that may be modified by the user in supporting information panels. Each event will also contain links to what-if challenges that may be presented during the event.

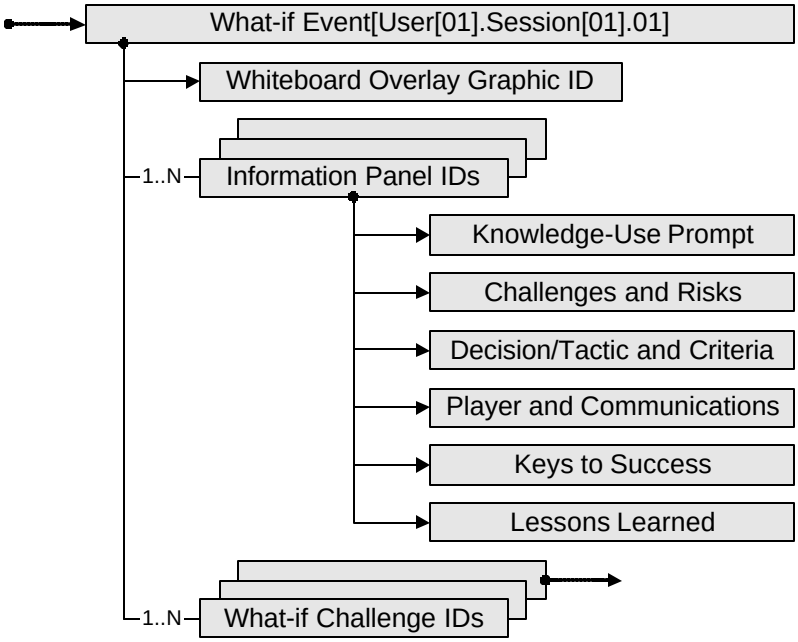

Figure 7. **What-if Event Data Model**

What-if Challenge. Each what-if challenge will define a particular difficulty level, mission phase and the emphasized knowledge category for the corresponding event.

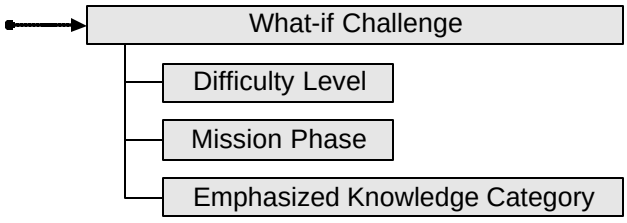

Figure 8. **What-if Challenge Data Model**

Application Navigation: the Behavior-Model. The C3PI application context is defined in the time domain. As the training session proceeds, the application will progress from the 'current state' to a logically successive 'next state'. The user may intervene and interact with the application independent of the state sequence. The user may, at appropriate stages in the application, invoke specific functions such as displaying expert advice video clips.

These application flows will be captured and represented as a behavior-model. The transitions through the application states will be invoked by the user. This does not preclude the ability to support autonomous transitions, such as timed exercises or slide-show presentations. These transitions may not necessarily compose a single-thread

sequential sequence, but may require that the user branch or navigate back-and-forth through the session.

The user may choose to deviate from the 'nominal' session sequence by interacting explicitly with the application. The nominal sequence will be internally represented in the application. This facilitates ease of use in that the user does not need to progress through the sequences by opening files and pressing specific buttons. The nominal session sequence is illustrated in Figure 9.

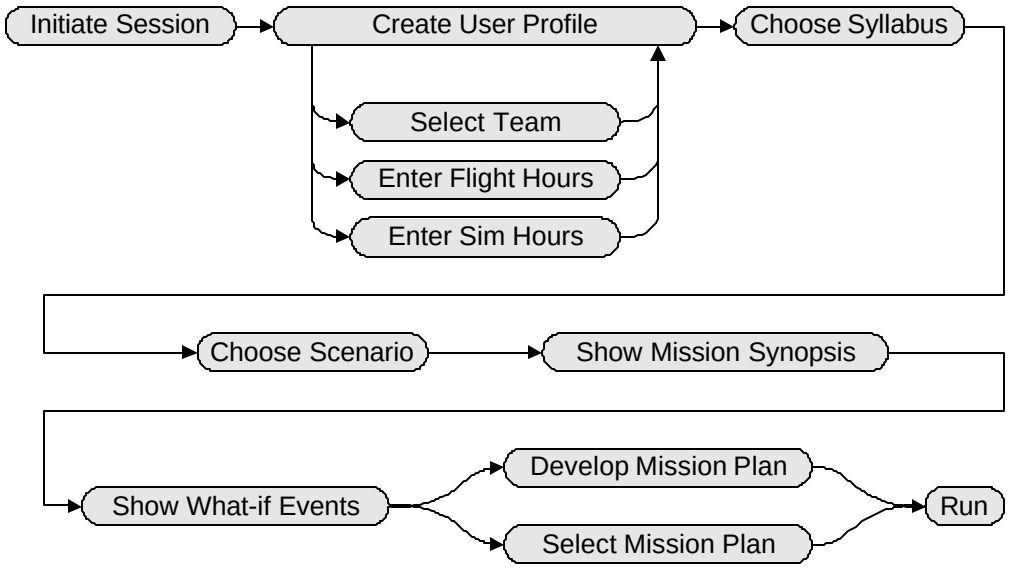

Figure 9. **Nominal Session Sequence**

User Interface. The user interface design presents the typical challenges incurred when presenting interactive information and control elements on a graphical screen of limited size and effective resolution. Upon considering the requirements of the C3PI system, the user interface may be decomposed into four functional areas:

- Scenario Pane: A large region for displaying static and interactive graphics and whiteboard emulation.
- Video popup Window: A temporary region for displaying video clips.
- Supporting Information Pane: A region for presenting dynamic runtime-variant information.
- Control Tool Bar: A region used to present frequently used navigation controls.

There exist opposing forces in arriving at an optimal user interface. For example, it is a foregone conclusion that the C3PI application will use the graphical interface provided by the Microsoft Windows desktop operating system due to other design drivers. The guidelines for effective use of this interface, provided to Microsoft application developers, prescribes consistent use of the various graphical elements

(buttons, edit-boxes, lists, etc.) whenever possible. Applications designed in compliance with these guidelines provide an intuitive look-and-feel and, therefore, require less training as the user community matures on the Microsoft Windows platform. The opposing force is due to considerations when contemplating the usability of C3PI. Those recommendations prescribed by Microsoft may be deprecated when considering particular use cases of the C3PI application, leading to evaluation of alternate approaches. The initial C3PI application screen concept is illustrated Figure 10. This concept represents the straw-man approach that will be used to iteratively design the optimal user interface.

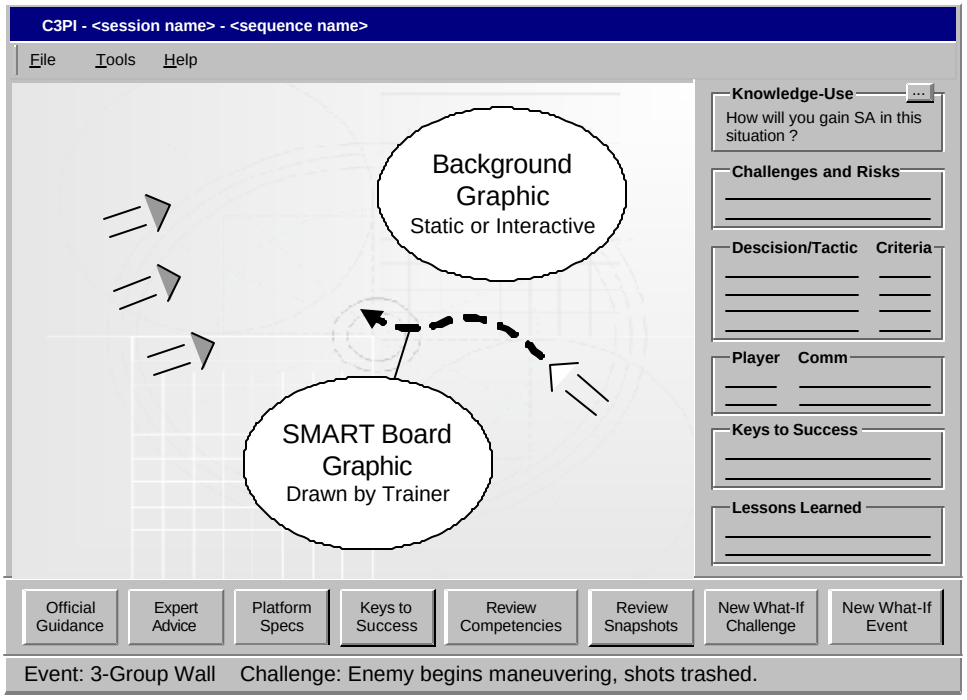

Figure 10. **Evolved Application Screen Concept**

RESEARCH CONTRIBUTIONS

This section of the report describes domain analysis research conducted using CTA methods to guide the C3PI design and research issues and plans that will be pursued in Phase II of this research and development effort.

Phase I CTA Research

To support the development of the C3PI conceptual design, CTA-based research was conducted during Phase I. This research had the goals of exploring the links between planning and mission execution and contributing to the development of training content to be used in C3PI. For this research, an interview protocol was developed to

support an event-based CTA approach (e.g., Fowlkes, Salas, Baker, Cannon-Bowers, & Stout, 2000). We used a CTA approach for three main reasons. First, this approach facilitates the identification of rich task performance details and provides a means for representing those details in ways that reveal important relationships and patterns in skill and knowledge usage. Second, the rich task performance details and knowledge representations obtained using this type approach can support the development of a number of training-related products including performance measures, training scenarios, performance critiquing tools, training and performance aids, and feedback content. Third, the C3PI project team has significant experience conducting CTAs of this type. The CTA included a front-end domain analysis and subsequent development and implementation of the event-based interview protocol. These are described below.

CTA techniques can yield a large amount of very detailed information. So that the analyst does not end up transcribing, representing, assessing, and ultimately filtering out large amounts of interesting but irrelevant data, it is essential that the CTA technique(s) target the correct information. Therefore, we initially performed a front-end domain analysis. This analysis included documentation review and unstructured interviews. For the documentation review, we drew upon the mission planning and aircrew training literature (especially reviews, e.g., Blickensderfer et al., 2000; Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995; Nullmeyer et al., 2000), including naval air wing team coordination research we currently are conducting, to identify knowledge and skill categories that have been proposed and/or evaluated in past research efforts. We also made use of reports and data generated by the operational community and DMT research to obtain insight into aspects of mission performance that are affected by planning and to further assess the skills and knowledge used to effectively plan during mission execution.

Second, the front-end analysis was supported by high-level interviews with aircrew members. Specifically, two background interviews were conducted (with one SME) to provide a better understanding of DCA missions, including the planning and briefing processes associated with them. These interviews, as well as the documentation review, were utilized to develop the event-based interview protocol that was subsequently implemented with two SMEs (the SME used in the initial interviews and an additional SME).

The intent of the event-based interview was to provide experts with deliberate and controlled job situations, allowing investigation of specific task aspects and the comparison of expert responses. The event-based interview protocol involved presenting SMEs with tactical situations that would provide rich contexts within which they could describe links between planning and execution. This protocol allowed us the opportunity to identify important cues, knowledge, and, importantly, links between execution and the planning process. Further, because different SMEs will each have experienced somewhat different situations, tried different strategies, and used different cues and data, and because different SMEs will recall and verbalize information differently, presenting multiple SMEs with the same event and amassing data from all of them that is specific to that event is critical to building a complete and robust picture of

task performance and its cognitive elements. Table 1 provides examples of the event prompts that were used in this interview protocol. The complete interview protocol is provided in Appendix A.

Table 1. *Example Event-Based Interview Prompts*

- During the CAP (combat air patrol) phase, you find out that #2 and #3 have an alibi – neither has working radar.
- During the merge preparation phase, #3 makes confusing sorting comms as you sort against 4 hostile aircraft and you are not sure if he is targeting the one you wanted him to target.
- Hostile aircraft have been trying to engage you in cat and mouse game. Fighters in the "next lane" have fallen out so now you have to cover their lane.

Two SMEs participated in the event-based interviews. For each situation presented, each SME was prompted to recall specific situations, similar to the events presented, with which they had personal experience. The SMEs were also prompted to link the execution experiences recounted to the planning and briefing process. This interview technique is a variation of the Critical Decision Method (CDM; e.g., Klein, Calderwood, & MacGregor, 1989) that facilitates the comparison of SME responses and the accumulation of SME responses for a given set of prompts. CDM is designed specifically to access knowledge that accompanies expertise and, as a case-based technique, takes advantage of human tendencies to use storytelling as a means of conversing and communicating and to use stories as a means for storing and describing memories (e.g., Cohen, Freeman, & Thompson, 1998; Jonassen, Tessmer, & Hannum, 1999).

Each of the interviews was synthesized to extract key processes in planning and execution. These key processes were used as categories for assessing the data and are summarized in Table 2. Specifically, interview data were parsed into these key planning and execution process categories and then coded with respect to the knowledge categories listed in Table 3. These knowledge categories were derived based on iterative assessment of the data collected and CTA research conducted with naval air wing aviators (Neville et al., 2002), and they closely correspond to C3PI knowledge categories and knowledge-use prompts. Thus, knowledge verbalized during these interviews can be used to support the development of these categories and the associated training.

The interview analysis syntheses are included as Appendix B. In summary, the event-based interviews conducted in Phase I served to increase our domain knowledge and help us to identify the links between planning and execution. Further, we anticipate that they will be used to develop specific C3PI training content during Phase II. In addition, this effort resulted in an interview protocol that may be utilized in the Phase II effort. One of the two background interviews conducted as part of the front-end analysis was recorded and transcribed and was also assessed using the categories and codes listed in Tables 2 and 3. These interview data are included as Appendix C.

Table 2. *Categories of Information Extracted from Interviews*	
Category of Information	**Category Description**
Planning elements and organization	Interviews were analyzed to identify key elements of the planning process and identify how the planning and briefing processes are organized.
Planning strategies that support execution	The interviews were synthesized to reveal planning strategies that support execution. Examples of strategies identified included use of simulation/role playing to ensure team members understand communication, targeting and sorting; use of visualization to build a similar mental picture among team members; and use of standardization and contracts.
Variations in planning and briefing	The interviews were synthesized to identify ways in which teams may differ. For example, one SME identified "what-iffing" as a strategy used by good teams. Another example concerned differences in the briefing style of the flight lead.
Execution challenges	Execution challenges were identified to better understand how planning may help to overcome them. Examples of execution challenges included communication, maintaining situation awareness going into the merge, and radar mechanics.
Execution strategies	Execution strategies were identified to better understand how planning may help to overcome them. Examples of execution strategies included methods for conducting "cold ops," and ways to task wingmen.
Knowledge that supports execution and planning	Knowledge that supports execution was identified. Knowledge identified pertained to knowledge of other elements, enemy threat capabilities, and examples of execution templates, for example. This information will help the team to further understand the knowledge that supports execution and that links planning to execution.
What if examples	Additional what-if examples were identified that might form the basis for "what if" events and challenges included in C3PI.

Table 3. ***Categories of Knowledge Used to Code Information Extracted from Interviews***

Initial SA (SA)
- How will team build SA about this situation?
- What needs to be done and said and by whom?
- How will AWACS describe this configuration over the radio?

Decision Points and Criteria (DPC)
- What are the decisions?
- Who is the decision maker for a given decision (e.g., AWACS or Flight Lead)? Will decision maker need help recognizing that criteria were met?
- Are the decision criteria consistent with the risk acceptance level?
- What could team members do or say to prevent the what-if situation from reaching abort (or other negative) criteria?
- Are there steps you can take to build an adaptive mindset to facilitate the required shift in the plan when criteria are met?

Timing and Flow (TF)
- Who should be where? How should they be flowing?

Mutual Support (MS)
- Who needs support during this situation?
- How will the support need be recognized?
- Who will provide the needed support and how?

Enemy Tactics (ET)
- What might the enemy do next in this situation?
- How can you be best positioned to respond?

Limitations (LM)
- What factors might limit your ability to detect or respond to this situation?
- What can the team do to counter identified limiting factors?

Knowledge of Distributed Teams Capabilities (DTC)
(GCI, F-18s, F-5s…)

Knowledge of 4-Ship (K4)
(Load-Out, Gas, Capabilities, Limitations, Roles, Responsibilities…)

Past Experience (PE)

Mission Execution Elements (MEE)
(Bounding Range, Package Criteria…)

Hypotheses about the Cognitive Elements of Planning Expertise

During Phase II of this effort, we propose to conduct additional research to explore the planning strategies and skills associated with effective team adaptability in dynamic environments. More specifically, we propose to conduct CTA-based research

to examine the processes by which flight leads with different levels of experience and their teams conduct the what-iffing and contingency planning phase of plan development. The research will be used to examine planning process data and look for differences associated with experience level in cognitive processing activities (e.g., situation assessment, analogical reasoning, analytical decision making, option generation, etc.), in the use of cognitive strategies (e.g., prioritization, memory enhancement, and decision making strategies), and in the use of knowledge throughout the what-iffing and contingency planning phase of planning.

This research is designed to answer questions such as: What strategies and types of knowledge do experts use to question assumptions? to build shared mental models? to identify problem areas? In addition, this research will address planning process hypotheses suggested by the cognitive research literature. A sample of these hypotheses includes the following:

- If experts have more and richer domain knowledge of certain types (e.g., Doane, Pellegrino, & Klatsky, 1990; Neville et al., 2002), when and in what ways do they use those types of knowledge to more effectively what-if and plan for contingencies?
- Do expert planners tend to engage in a more thorough analysis of the what-if situation and constraints before trying to develop solutions, as has been demonstrated in other domains (e.g., Chase & Simon, 1973; Chi, Feltovich, & Glaser, 1981)? If so, what are the characteristics of this preparatory analysis and what aspects of it represent challenges for novices?
- A cognitive model of planning proposed by Hayes-Roth and Hayes-Roth (1979) suggests that planning is characterized by opportunistic decision making and strategic alternation among levels of abstraction.
  - Are there expert-novice differences in the amount or quality of opportunistic decision making during what-if planning?
  - Are there expert-novice differences in the use of abstraction levels during the what-if and contingency planning process that are associated with mission performance? Research conducted by Spiker and his associates (e.g., Spiker & Nullmeyer, 1995; Spiker, Nullmeyer, & Tourville, 1997) suggests such differences may exist. For example, they found that superior plans tend to be planned 'from big to small' and that effective planners are better able to determine the appropriate level of detail.
- Analogical reasoning has been shown to be an effective and commonly-used form of problem solving (e.g., Chen, 2002; Gentner, 1983) and it is relevant to the planning domain. For example, Spiker et al. (1999) noted that effective planners drew upon past experiences during planning. How and when do experts versus novices use analogy to guide planning during what-iffing and contingency planning?
- Memory research has shown that information processing and presentation strategies affect memory of the presented information (e.g., Jacoby & Dallas, 1981). Compared with novices, do experts use more or different types of

perceptually- and/or conceptually-driven planning and briefing strategies (and what are those strategies)?

The results of the CTA research will be used to refine the C3PI design and add to its training content. Specifically, each experience-related process difference identified would be assessed to identify an appropriate training strategy, which could then be incorporated into C3PI. In some cases, a difference could be addressed by inserting new types of what-if events or what-if challenges into C3PI databases. In other cases, new planning tools might be implemented (e.g., to aid in the use of certain perceptually- or conceptually-driven planning strategies) or attentional advice might be added. In still other cases, *knowledge categories* and *knowledge use prompts* may be refined or expert advice video clips may be added (e.g., to describe using analogies).

Phase II Research Plans

To explore the above hypotheses and investigate the cognitive elements of planning expertise, we have proposed to conduct CTA-based research during Phase II, as noted above. The focus of this CTA research will be on the planning processes associated with what-if and contingency planning. We anticipate that the data and results obtained will indirectly influence and directly feed into C3PI content and design. The research objectives are to:

- characterize what-if and contingency planning processes in terms of their cognitive elements;
- identify experience-related differences in what-if and contingency planning processes and their cognitive elements; and
- identify a subset of mission preparation measures based on the identified experience-related differences.

During Phase I, we utilized a CTA data collection protocol that was designed to link mission event successes and difficulties to mission preparation processes. This protocol, described in the preceding section, provided insight into high-level mission preparation strategies. However, the protocol is not suited to revealing the more detailed information about planning processes and experience-related differences that we now seek and plan to use to add to the C3PI training capabilities.

Consequently, we are proposing to use a different data collection strategy during the Phase II research effort. Specifically, we hope to observe tactical team planning sessions (preferably air combat team planning sessions) and videotape the what-if and contingency planning portions of each session (we would videotape the entire session but only use the what-if and contingency planning portions). As soon after the planning session as feasible, we would play back those portions of the planning session with the team lead while asking him to elaborate on what he is doing in the video, why, and how. His descriptions of the planning activities would be audiotaped. We proposed to conduct this data collection using six planning teams with team leads of varying levels of experience.

Collecting planning process data is critical to meeting the objectives of this CTA. However, if the data collection plan just described is found to not be feasible, an alternative plan will be developed based on the data collection constraints. One such alternative is to collect data from teams in a different mission planning domain that can support the resource requirements we describe (i.e., teams that are not in the air combat community). Another is to arrange for AFRL SMEs to hold mock planning sessions. Alternative data collection plans that require fewer resources include collecting only the planning videotape data and not the follow-on interview data and decreasing the number of participating teams. Each of the identified alternatives is associated with significant trade-offs that will affect the quality and reliability of the CTA results. Consequently, finding air combat teams who will accommodate our proposed data collection plan will be given high priority and immediate attention at the outset of the proposed Phase II effort.

Although data from additional teams would improve the reliability of the research findings, they would also increase both the risk and cost associated with the research. CTAs can be very time consuming, especially when they are focused on a low level of analysis, as in this case. Furthermore, it can take as much as a full working day for an expert typist to transcribe 1 hr of an interview (Hoffman, 1987), and we will most likely not be able to outsource the data transcribing to a dedicated transcriptionist because of its classified nature. Hence, we have chosen six as the number of teams we propose to study because it represents a number that is, based on our past CTA experience, large enough to support the types of analyses we plan to conduct yet small enough to be completed in a reasonable period of time (estimated timeframe is 8-9 mths).

The CTA data analysis phase will involve transcribing the videotaped and audiotaped data and parsing the transcriptions into tables of data elements, each data element representing a single concept or piece of knowledge. Audiotape data will be represented in the same table as the videotape data for a given team. Because the audiotape data is supplementary to the videotape data, the data elements from these two sources will be represented in parallel columns so they may be considered together across the planning timeline.

Data for all six interviews will first be reviewed to gain insight into patterns and trends across the planning process. Based on this insight and the results of the Phase I research, hypotheses about the cognitive principles of planning and experience-related differences in planning principles (e.g., those described in the preceding section) will be specified. To facilitate the analysis, analysis guidelines for evaluating each hypothesis will be developed. These guidelines will provide guidance for identifying data elements that contain evidence relevant to each hypothesized cognitive principle and experience-related difference. The data elements of more and less experienced teams and team leads for a given hypothesis will be compared qualitatively and quantitatively, in ways specified by the analysis guidelines (i.e., based on the affordances of the data). Qualitative assessments might include assessing the data to identify uses of analogy. These assessments might be complemented by follow-on quantitative analyses of the

number of analogies used in each planning phase and follow-on qualitative analyses of the planner's goal in using each analogy, as an example.

FUTURE WORK

The Phase I work described above laid the groundwork for our Phase II effort, which will consist of conducting CTA-based research to investigate the cognitive elements of planning expertise, refining and adding to the C3PI design and content based on the findings of that research, implementing the design, and evaluating the value of the system, both in terms of perceived value by the user and more objective measures of performance and expertise enhancement. Specific objectives proposed for the Phase II work include the following:

- Incorporate cognitive principles of planning expertise into C3PI design and content
- Develop an intuitive user interface that supports training objectives
- Develop dual-use C3PI planning support and training tools
- Develop mission brief and after action review (AAR) support capabilities
- Integrate system components to produce a complete C3PI prototype
- Develop and evaluate the capability for C3PI to be used collaboratively by distributed teams

To summarize, the goal of this effort is to develop training for a critical phase of tactical mission execution that, to date, has been relatively neglected – mission planning. Further, this training will focus on the acquisition of mission planning expertise that facilitates team adaptability in a dynamic environment. This training will be provided on a training system (C3PI) that must be: (1) compatible with the DMT system; (2) easy for users to use in training and ultimately in real world planning environments; (3) robust; (4) designed based on sound research; and (5) found to improve measures of decision making and team coordination during unanticipated mission events.

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APPENDIX A

C3PI Event-Based Interview Protocol

Introduction (This is read to participant at beginning of interview)

We are conducting these interviews for an SBIR project aimed at enhancing DMT-based training to build expertise in planning. Through the interviews, we are trying to understand

What aspects of planning contribute to mission performance?
What aspects of planning contribute to replanning capability?

We are going to ask you about a series of events or problems that might occur during the conduct of a defensive counter air (DCA) lane defense mission flown by an F-16 4-ship. Our main interest is in how you would deal with each event and how the mission plan or the mission planning process would help prepare you to deal with each event. With respect to the mission plan and the planning process, we would like to hear about things experts do that would help the 4-ship deal effectively with a problem and about things less experienced people may do that may decrease the team's chances for success.

We would like to audio tape this interview. Also, we would like to begin with the assumption that it can be kept at an unclassified level. However, if you say something that is classified or think we should know about something that involves classified information, please let us know. We have permission to collect, store, and use information that is classified up to the Secret level.

To reiterate our objectives, we are going to ask you how you would deal with each of a series of events and how the mission plan or the mission planning process would help prepare you for dealing with each event. With respect to the mission plan and the planning process, we would like to hear about things experts do that would help the 4-ship deal effectively with a problem and about things less experienced people may do that may decrease the team's chances for success.

If you can think of specific examples of situations you have been in or heard about that are relevant to the questions, those would be especially valuable and helpful for us to hear.

Do you have any questions for us before we begin?

Events Posed (each event is followed by questions listed below)

1. During the CAP phase, you find out that #2 and #3 have an alibi – neither has working radar.
2. During the merge preparation phase, #3 makes confusing sorting comms as you sort against 4 hostile aircraft and you are not sure if he is targeting the one you wanted him to

3. Hostile a/c have been trying to engage you in cat and mouse game. Fighters in the "next lane" have fallen out so now you have to cover their lane.
4. Hostile a/c have been trying to engage you in cat and mouse game. Fighters in the "next lane" have committed on a group. You lose AWACS (AWACS goes midnight).
5. You've committed two ships to what you thought was a two ship, but breaks out to be a four ship
6. During the commit to the 4-ship, you stop hearing comms (or comms are degrading) and your SA drops.
7. During the merge preparation phase, #3 is inexperienced and begins to panic as you approach VID situation
8. During the merge phase, #2 breaks from your gameplan and targets hostile aircraft before getting into the correct position/location
9. During the merge phase, #3 breaks from your gameplan by going too far forward to target the threats instead of turning around at range (I think this is the same as one you give below) You are in a grinder. The plan was to leave at range. As you are wheeling around (to head back toward the threat), you see your friendlies mixed in with the threats in front of you, and you are not hearing comm.
10. Post merge, hostiles did not blow up like they were supposed to. You're "running away" and trying to build a mental picture.

<u>Questions Asked After Description of Each Event Listed Above</u>

1. Have you been in this situation before?
2. What would be one of the first things you would expect to hear? Why?
3. How could/did the plan or planning process contribute to successfully detecting this situation?
4. What would be an example of excellent comm in this situation by you, by your wingman, by AWACS?
5. How does the plan and planning process help prepare you for this type of effective comm?
6. What decisions would/did you make? What are the considerations?
7. How would/did the plan or planning process contribute to your decision?
8. What could/did go wrong in the team's reaction to this situation? What mistakes did/might the team or a team member make in dealing with this situation (if there are/were are many things, pick 2 or 3)?
9. How could/did the plan or planning process help prevent these things from going wrong?

In what other ways could/did the plan or planning process contribute to successfully responding to this situation as a team? Interviewer: listen for knowledge of constraints, flow/timing, teammates, own abilities and limitations, dynamic threat situation.

10. Can you think of 2 or 3 examples of shortcomings of a plan or planning process that would/did decrease the team's chances for successfully reacting to this situation?
11. Under what conditions might these shortcomings in a plan or planning process occur? Why might they occur?
12. What are your assets for building SA and how would you use them now? How does or should the plan help prepare you for this?

APPENDIX B

Event-Based Interview Data Syntheses for Two Air Combat SMEs

Notes. Knowledge category codes are defined in Table 3. Interview content represented in bold font are interviewer verbalizations.

SME 1

Description of Interview Content	Knowledge Categories	Interview Content
What-If Examples		
Wide Azimuth-group out of lane	SA	And you kind of brief in the scenario is, "ok, you've got a 4-ship of F-15s up here in the northern lane, a 4-ship of F-18s in the southern lane". Are they really out there, no, they're virtual entities in the sky. So what we'll do, we'll give them a very wide Azimuth that's 38 miles apart and what we're trying to do is see if he even recognizes that "hey, one of these groups is out of my lane".
Faulty radar	DPC, MS	get on CAP and somebody's radar isn't working
Sorting comms	DPC	you're going in to the merge or sorting and your #3 doesn't say something, or doesn't reply to your sorting comms, do 3 and 4 sort together or does it depend on how many fighters they're coming up against.
Next lane falls out	DPC	bandits are giving you a hard time and fighters in the next lane fall out, would you cover their lane
Style out of range	DPC, SA	If there are two styles and one comes up north that's out of your 30 mile range, is that still something you would take on
Two fighters have two packages	DPC, SA	What are you going to do if you've got 1 &2 and you've got 2 packages in the south, can one take one package and 2 the other, or do you just see which is closer
Targeting same package	SA, DPC	Have you ever been in a situation where you've been in a 4-ship and are targeting a hostile group and come to find out that somebody from some other group is targeting the same package
Same area as another 4-ship	SA	Have you had it where you're operating in the same area as another 4-ship from another lane…
Blue on blue	TF	A good blue on blue example…because that really relates to knowing where people are and where you need to flow coming out of engagements…
Plan Elements		
What-ifs	DPC, SA	Like I told the other groups when they ask me, it's the groups that think about the what-ifs, if you bring those out in the mission planning and preparation it really helps.
Commander's Intent	DPC	if you say "think about your mission, think about your risk level, think about what it affects" in that context I think that'll help a lot.
Bounding range/package criteria	MEE	My lane is 30 miles wide, so in my brief and in your planning, you should have a bounding range or package criteria.
Competencies	K4	You've got to focus on your primaries and you actually get better when you get into the supporting competencies,

		knowledge and skills.
Contingency Planning	DPC	It's all contingency planning
4-ship involvement	K4	The entire 4-ship should be part of the mission plan, should be part of the brief
Priorities in comms	MS	But if you really illustrate, "guys, if no one's defensive, threat or spike and you hear someone call blind…" you really go through those situations and you point it out.
Bullseye, enemy tactics	ET, MEE	If they don't talk about it and the flight lead doesn't get up and say "hey guys there's an SA-2, SA-6, SA-8 blah blah blah, guess what, we don't want to be anywhere 15 miles closer to bullseye. We don't need to be there, so don't let them lure us in".
Enemy tactics	ET, K4, DPC	So mission planning and you see groups go out there going and killing everything in front of us and they just trundle in and the red air doesn't get them, the SAMs do. Or vice versa, they'll start paying such attention to the SAMs, that the red air gets them. They didn't mission plan, they didn't think about it, they didn't say that's not their mission to go and do that and I think you'll see that a lot.
Plan and Brief Organization		
What-ifs, no missiles, no radar	DPC, MS	Usually guys reserve this for the end of the brief, let's say things start going wrong, we're down to one person in the element has no missiles, very similar to someone having no radar and then build a plan from right there.
Cold ops priorities	TF, SA,	and the best ones I've seen is in that Cold Ops or something like this, a guy spent a good chunk of the brief, talking about that. And it was almost a laundry list; this happens first, then this, we all get together, once we're all together, now I say GCI picture. Everybody shuts up, GCI paints the picture, if I don't understand it, I'll ask a question or I'll call out from Viper 1 to the nearest group…and you've heard all these things talked about and said, now everybody's got the picture, here's the game plan, Viper 3, you'll pitch back first, target blah blah blah, any questions, silence, execute.
Variations in Planning and Briefing		
What-ifs	PE, DPC	I've worked w/the other groups that have come through the mission planning cell and it's the groups that talk about these type of things that go wrong that do the best. And they have a plan.
Commander's Intent, background info	MEE	I'll start out the brief and give a big overview of what we're going to do and maybe the intel officer will come up and give the intel report for the day. And I'll go "ok guys, the big picture today, we are DCA lane defense, we're defending this lane, here's the parameters, here's what we're due, here's our weapons load-out, here's what we're expecting to see" and everything like that. And now I'll grab the contracts card and I'll go…because most of this stuff is standard.
Lead techniques	N/A	There's two different schools of thought by they way, that's all briefing techniques. Some people like to get up there and just say, "I am king, listen to me preach" other people like to say, "3 what are we going to do, or GCI, call this picture out" practice and get them involved right then.
Presentation strategies	N/A	It's techniques there, it's however you want to do it. You're talking to a map, or at least draw it up on the whiteboard and

		they'll talk to it when they have Rodan in the north and this person in the south.
Flow of elements	TF, DPC	If you get a good lead that briefs and knows the mission and knows the plan and talks about where the other blue groups are, the other folks, that usually eliminates that, still happens, and then you also go into the what-if stuff goes wrong and we're separated, how do we fix that.
Cold ops, post-merge	DPC, MS	Bringing it back to our mission and what we're trying to do. 4-I don't want you running west bound if we're DCA lane defense in the (?) war, you do me no good out there alone, so as long as you're survived, and if I illustrate this, now I avoid the blue on blue and I get people thinking about that, as long as you're surviving and you're not spiked anymore, start heading back west and you'll even hear guys brief for the cap plan "ok, you're alone and afraid and everything's going bad. If you're defensive, run back to the cap, first one there mans the cap, set up cap there and someone will come back and find you, or we'll all regroup".
Leadership		
Lead characteristics	PE	The lead makes a huge difference because it's going to come across in the briefing, and you've probably sat through some and witnessed enough to know a good one from a bad one. Just from body language, affirmation in what you're saying and what everyone's going to do, and then during the execution of the flight, it's that flight lead that's been in that situation before that his photo album is full and his brain…or he's at least given it enough thought to react to it quickly and that stems from mission planning and briefing.
Sorting	K4	Or if in real time I just hear them say "4 sort leaders" I say "negative, 4 sort trail". And you step on it.
Intercepts	SA, K4	As a leader, I need to know where all these folks are, I have to run my intercepts to these trailers.
Lead		But I'm orchestrating the whole thing, I'm up there the conductor, I may ask the questions.
Flow of elements	TF, SA, DPC	If you get a good lead that briefs and knows the mission and knows the plan and talks about where the other blue groups are, the other folks, that usually eliminates that, still happens, and then you also go into the what-if stuff goes wrong and we're separated, how do we fix that.
Planning Strategies that Support Execution		
No radar, no missiles	DPC, MS	Usually guys reserve this for the end of the brief, let's say things start going wrong, we're down to one person in the element has no missiles, very similar to someone having no radar and then build a plan from right there.
Contingency planning	MS, DPC	Something like where you're in this big package and you don't have time to say "sorry guys, we're out", so now you need to figure out who's going to be the most experienced in the flight, you don't really want to renumber the flights, you just have to have this briefed
Contingency planning	DPC	It is a somewhat standard plan. It's in most folks' brief to say "you take the tact lead of that element, you're the primary shooter" whatever the case may be.
Sort plan	K4	I brought a brief in and a contracts card that gets handed out. You talk about your sort plan and your hostile and who's the

		owner of the group, who's the sharer of the group
Targeting	K4, TF	If I'm the primary person targeted in that flight and my entire flight is going to go tag it, it's my job to build the 3D picture for them so they can revert back to that knowledge and say "he told me it was a 4-ship container" so I would know as 4 I'd want to be on the far trail or on the leader, depending on what I do.
Radar assignments	K4, LM	Everybody's got to know, if our comm goes out or if we get comm.-jammed everybody should know where their radar should be from mission planning and the brief.
GCI info	DTC, SA	I'll tell GCI, "my 286 brain can only handle so much information at once, just tell me 'groups marshalling west of bull or 2nd package, north of bull, bullseye" and then say "leading edge is 2 groups azimuth 10, blah blah blah'" because that's all I can deal with now.
Practice Comms	SA, DTC	Hey, it's an interactive brief, hopefully "2 you see this, what are you going to say". Or more likely, in the event of the package situation which is what we're dealing with right now, someone outside of our area of responsibility, "GCI what are you going to call this" and I'll get an example of what he's going to say. If it's incorrect, I'll correct him right there on the spot
Frequencies	K4, MEE	One thing that we can bring out in this thing with the mission planning is talk about the UHF frequencies, the VHF frequencies.
Missile management	LM, K4	A DCA lane where what we call is WRM -war reserve man missiles, anyway, your missile management, I've only got a certain number of beyond visual range shooting missiles amongst my 4-ship, so I just can't go out there and the first thing I see, start wailing away. I have to think about conserving those, so yes if I had a group double targeted, and I've got two people shooting two missiles each into that group, that's four missiles that may or may not only kill one or two people. I've just cut down my missiles by 25% and that's a big part of it. Segue is, in discussing what I'm trying to accomplish here, bring up what the weapons load is.
Comm priorities	TF, K4	It kind of goes back to comm.-priorities which is mission planning which is talking about frequencies and what really, really helps, and we get into it a little bit here, but is in the mission planning, knowing where everybody else is.
Cold ops	TF	Cold Ops, what happens then, what is my flow, what is my mission and that kind of goes all the way back to mission planning.
Flow	TF	And flow, what is my mission? Well, that should have been totally obvious before we even stepped in the jet.
Fighter presentation	PE, SA, K4, TF	I've seen groups go "let's grind today and let's do this" and they don't talk about it…and sure enough, pitch back in, "declare group blah blah blah" and one of two things happens. Either they waste all their brain bytes and SA on figuring out that that's 1 &2 and if I had talked about it in the brief and mission planning…
Team participation	PE	You kind of get the feeling that the more everyone's involved in the plan, obviously the better off we're going to be.
Flow of strike package	TF	They say "hey we'll have Rodan in the north and this in the south and 20 miles behind us will be this group" and if I'm the

		OCA sweep I'll say "hey these guys are starting 40 miles behind us, so we have…we'll be able to push out, kill everything we can, but if you get in a bad situation, you can only abort once but we've only got one minute cold because strike package is going to be on our nose in a minute".
Flow	TF	We either have to tell them to spin or we need to be aware that those are the good briefs, that's when everybody's going "we're in a mission here, we're in a flow, we need to know where our flows are, what's going on".
Communication-cold ops?	SA, MS	If you don't know where you are or what's going on, start heading back towards the cap, head back towards the cap and start talking to someone. When they start talking, everyone else, if you're not in one of these other priorities where you're defensive threat spiked or getting a declaration, shut up. So the other guy can talk, his element man can find him, then the whole 4-ship…"
Comm priority-group flow	TF, K4, SA	So you avoid those when the guys go through these and go over comm.-priorities and go "here's the situation, 3 &4 get separated…" and that's when you see it happen a lot. 3 will go "declare group blah blah" and it's 4 because they don't know, they haven't talked, they haven't allowed this to happen by knowing what may happen.
Comm priority	MS, K4	But if you really illustrate, "guys, if no one's defensive, threat or spike and you hear someone call blind…" you really go through those situations and you point it out.
Cold ops comms	K4, DPC, TF	And the best ones I've seen is in that Cold Ops or something like this, a guy spent a good chunk of the brief, talking about that. And it was almost a laundry list; this happens first, then this, we all get together, once we're all together, now I say GCI picture. Everybody shuts up, GCI paints the picture, if I don't understand it, I'll ask a question or I'll call out from Viper 1 to the nearest group…and you've heard all these things talked about and said, now everybody's got the picture, here's the game plan, Viper 3, you'll pitch back first, target blah blah blah, any questions, silence, execute.
Commander's Intent Blue on Blue	DPC, TF, MS	Bringing it back to our mission and what we're trying to do. 4-I don't want you running west bound if we're DCA lane defense in the (?) war, you do me no good out there alone, so as long as you're survived, and if I illustrate this, now I avoid the blue on blue and I get people thinking about that, as long as you're surviving and you're not spiked anymore, start heading back west and you'll even hear guys brief for the cap plan "ok, you're alone and afraid and everything's going bad. If you're defensive, run back to the cap, first one there mans the cap, set up cap there and someone will come back and find you, or we'll all regroup".
Enemy capabilities	ET, K4	But if we bring out…we do this in our Intel scenario, "you're going to have maneuvering bandits, they're AMRAM aware" or whatever the case may be, so they're going to try to defeat you…so now you need to think about, we could bring out "hey guys, think about your missile WRM, how many missiles you have in the flight."
Enemy capabilities	ET, TF	If they don't talk about it and the flight lead doesn't get up and say "hey guys there's an SA-2, SA-6, SA-8 blah blah blah, guess what, we don't want to be anywhere 15 miles closer to

		bullseye. We don't need to be there, so don't let them lure us in".
Enemy threats	ET, DPC	So mission planning and you see groups go out there going and killing everything in front of us and they just trundle in and the red air doesn't get them, the SAMs do. Or vice versa, they'll start paying such attention to the SAMs, that the red air gets them. They didn't mission plan, they didn't think about it, they didn't say that's not their mission to go and do that and I think you'll see that a lot.
Execution Challenges		
Contingency planning	DPC, MS	Now you're really thinking "we can no longer be as offensive minded as we wanted to be, we need to go out and say…#1 would be the primary shooter, and 2 would just hang on and don't loose sight. Now #3 has to kind of give #4 (who's probably the youngest guy on your flight w/the least amount of experience) has to be able to say 4, lock here without knowing what's out there, shoot as many as you can and we're going to leave by a certain range".
Contingency planning	DPC, MS, LM	If I have a really, really inexperienced #4, now I may do the 2 and 4 swap although that's a lot more difficult logistically and to make that happen w/out all the confusion and now renumbering the flight or something like that.
Lethality, commander's intent	DPC	So now I have to think, "oh my gosh, not only can you not shoot anyone air-wise, he has to go on very limited bomb dropping capability when he gets to the target". So is it even worth it to me to bring him along. Or do I just say "go home" and now I'm a 3-ship.
Communications	K4, LM	If that's happening in the air and I recognize it, realize everybody sounds great outside of 15 miles, it's 15 miles and in when things that start getting confusing and there might not be that com time to correct #3.
Contracts	K4, LM	I'd hopefully fix it from my brief and I have a contracts card and I'm already planning what I'm going to say to 3 in the debrief when I get out because he's obviously messed up. If I have the time, I'm going to correct him in the air, has it happened, yes. Situationally, you've really described the situation right here and 90% of the time you don't have time to correct it, if you even recognize it.
Sorting	TF, DPC	They're out there in a supporting role, I'm coming in to ID this group and I hear 3 say "4 sort far trail" just as an example or "northern trailer" or "southern trailer" in this case would be a better thing. Then I know that 3 just put 4's radar right where I'm going and that's not good. "Negative, 4 sort southern region" in that situation.
Targeting/sorting	MEE	As far as targeting sorting, that's where we make our money, so to have a mistake on that should be just that, purely a human error and mistake.
Frequencies	K4, DTC	What happens a lot of times is people are using different radios, different radio freqs, usually there's one big package strike frequency, but kind of the rules of engagement are keep that as clean as possible
Listening skills	LM, K4	First thing that drops out of everyone when you're flying out here is your listening skills. Your SA starts to go away, you stop listening and you're on transmit only and not receiving any information.

SA	SA, LM, K4	People get in the same part of the sky because SA has gotten lower and lower and lower or a critical piece of information was set across the wrong radio frequency.
Teammate limitations	DTC, LM	So they [GCI] might not even recognize that 2 people are going after the same person. You would hope they would, but they may not.
Flow, teammate positions	TF, K4	What's going to happen in the groups is you're going to get about 20 miles apart and so guess what, if I haven't really illustrated to my number 2 or number 4 who may have never executed this game plan before, guess what, we're cold and we turn back hot-there's going to be a group, 20 miles on your nose, Hot. Guess what, that's 1 and 2…
Communication-listening	K4, LM	What doesn't happen a lot is all that instruction, no one hears what's going on because they've got their own things they're dealing with and it all breaks down and someone ends up targeting someone else.
Cold ops	TF	Cold Ops is "ok, we lost four" or "we're all cold and we know they're right behind us, first thing we have to do is figure out where everybody is…everybody shut up, viper1's here, 1 and 2 are holding hands…3 does the math and says, Viper 3 is your right, 2 o'clock, 10 miles. Ok, 10 miles going this way, everybody head 0-7-0."
Execution Strategies		
Loss of radar	K4, TF	#3 loosing radar is a lot bigger issue because they're an element lead of that element, they're an integral part of the game plan because #3, at least the way we're doing things now, is really a fill-in person. I'll put 2 &4 in certain spots and 3 catches whatever's coming out of that.
Missile load	K4, DPC	Just like, if I had a wingman, and we've done a couple pushes and I have a wingman who's out of missiles, I may swap wingman so at least one element has missiles. Same thing w/the radar.
Sorting, prioritization	K4, MEE	In reality there's so much input, you've got to learn to prioritize that [sorting confusion]
Radar, authority	DPC, K4	1's really running the flight, but when 3 &4 get on their own, 3 controls 4's radar so there's a certain level of autonomy there that you have to respect, but if you're going in as 4, 1 now becomes "hey, you do as I tell you, I own everybody's radar technically" and if I hear 3 doing something I don't want, I hopefully have corrected that in the brief so that everybody's radar goes where it should and 3 directs 4 correctly and if he doesn't, then I correct him if I recognize it.
Building the picture	K4	Me as a leader going into a tacts-formation it's my job to build the 3D picture for everyone else in the flight.
Radar position	K4	So where I want my radar and my wingman's radar, 2 or 4, being the leaders is I float the trailers and I identify them
Spiked	TF, MS	These things at the bottom are what usually get left out. Because some people go "help, I'm on fire, I'm spiked" but the first thing is survive, then element mutual support, then get untargeted strikers then the next threat
Surviving	TF, SA	Surviving may be running towards bad-guy land first because I know there's bad guys that I missed back this way, so I may have to run this way
SA, communication	MS	And then you go, ok, now what, where am I, "viper 4 is blind,

		bullseye 1-8-0 15" everybody goes, ok, he's blind, we need to get back the element mutual support here.
Comm priority	MS	No one else has anything like this, no one is defensive, no one is threatened, that already happened, no one needs a spike range, no one's declaring, so ok, you guys have the comm.
Knowledge that Supports Execution		
GCI capabilities	DTC, MS	He's (#3) not going to be able to know what that range is or how close they are since he doesn't have a radar. In this situation it's very important to tie GCI in. This is why in the mission planning part of it, you want to talk about these things so you're not just rolling in the air. Now GCI can play a role, tell #3 how close they are to the nearest threat, really help with targeting #4 in that situation.
Mission type, radar status	DPC, K4	For instance, we were talking about the differences b/t lane and point and sweep, this [no radar] is obviously a huge deal if we're sweeping. And we've got to go forward and we're not only thinking about air threats and ground threats.
Mission type	DPC, MEE	Where this also makes a player, and I know we're focusing on DCA lane, now if 2 and 3 loose a radar, that has so many more ramifications to me if they're dropping bombs because the radar's integral to that as well.
Mission type/commander's intent	DPC	If I loose two of them, now I'm a 2-ship and I really loose my lethality and I need to think about do I really need to be there, period.
Commander's intent	DPC	In a DCA lane, I'm probably going to be medium [level of risk] which means I'm probably not going to go to any merges that I don't have to or that I don't think I can survive out of
Commander's intent	DPC	Well no, if I'm in a point defense and I've got mom or dad and the kids back on the ground, then I'm going to go to any merge that I have to and then my risk level is high.
Contingency planning	PE, LM	And you have to see situations and be presented with things or you need to have thought them out so well beforehand that reacting to them is second nature.
Teammate characteristics	DTC	Well guess what, it'll get you in trouble a lot too because there may be this golden piece of information that's out there that people are afraid to say because "last time I said something about that, I was wrong, and I got crapped on in the debrief".
Limitations	DTC	Because most of the time AWACS does not hear the VHF
Teammate capabilities	DTC	I need to know who, what capabilities are out there, are you guys HARM shooters, or are you…what's your weapons load-out, what's our weapons load-out, all that stuff.
Team capabilities	K4	F-16s are limited a little bit because of their ID capability and not necessarily able to ID friendly
Team capabilities	K4, DTC. LM	It happens here a lot and guys a lot of times chalk it up to visibility, or else they would've been able to see. Well, guess what, you wouldn't have been able to see and you wouldn't have been able to tell that was an F-16 versus an F-18 versus a whatever because you're not.
Capabilities	DTC, K4	So much of this goes back to knowing who's out there.
Team capabilities	DTC, TF	So, it kind of goes back…mostly it happens when you're in the big packages and you don't know where other groups or entities are.
Procedure	K4, SA	And a lot of that stuff, you have to know, getting the element

		back together, will happen on VHF. All the other stuff will happen on UHF, you have to listen to both, know where to talk on which one, what you'd say and then Viper 3 would say "ok, I'm 10 miles, you're right 4 o'clock, come back right…" and now hopefully you'll get back together.
Enemy threat capabilities	ET, K4, LM	But if we bring out…we do this in our Intel scenario, "you're going to have maneuvering bandits, they're AMRAM aware" or whatever the case may be, so they're going to try to defeat you…so now you need to think about, we could bring out "hey guys, think about your missile WRM, how many missiles you have in the flight."

SME 2

Description of Interview Content	Knowledge Categories	Interview Content
What-If Examples		
Alibis ▪ Practice as #2 becoming #4 because of: o experience mix o resource distribution in the two, two ships Listening and comms are likely to be a training issue because call signs will be different	DP&C, MS	Every once in a while a guy won't have a radar. If you have two bad radars, now you may have to start swapping within the elements. Fifty percent of your 4-ship probably won't happen, but I can see one (alibi) happening and then it really depends on who you're flying with--the experience level. *When switching wingmen*. There may be some comm issues as far as using the wrong call sign…the guy needs to make a mental switch from okay now I am number 4 versus 2 or what ever. If we lose radar or someone has no missiles or like one element has no missiles or no radar, we will get someone with a radar and missiles in that element. And that is pretty much all that needs to be said.
Present a situation in which flight lead loses radar. Present from these perspectives: ▪ flight lead has to use wingman's radar for tactical decision making. ▪ wingman has to communicate his radar information to the flight lead to support lead's tactical decision making	MS	*Flight lead using radar of wingman.* I'm using your radar. I'll make the tactical decision but I am using information that I listen to often, what you're saying to make my decisions on.
Because of poor radar mech, or poor comms, both 1 and 2 are sorted to the same (leader or trainer). Ask: Why is this bad? What can be done to be aware of this situation?	SA, L	So, one of you can be so clueless that he hasn't been listening or doesn't have the radar mech to know who the leader and trailer is, Or, two, he just says the wrong thing because of a brain fart. Now he will be sitting there not really knowing. What that may mean is that if you think that he has sorted on the leader, okay, which is two airplanes, one or two miles apart. He says he is sorted on the leader but he really sorted to the trailer. Okay, he may bring the radar into the trailer, what about if the leader goes like this (splits). Now he goes away. Because I depend on him to tell me what is going on with certain individuals. Maybe they went like this and started splitting and I didn't know that because all of our radar went with this one guy. Obviously that is a problem because we have no SA on that free fighter. That's not good. So, it does come down to communication.
Based on a situation presented, ask, "Based on sort matrix, where is your sort going to be?"	T&F	Sometimes you draw little pictures up. I'll draw pictures up and go, "Okay, if we see a two-ship line abreast, what's the sort going to be?" And you just talked about your sort matrix—side/side, near/far. So, where's sort the going to be to? And you look right at him. And he goes, "Okay my sorts

		going to be there." And you go "Very good."
Show an engagement and the beginning of the cold ops period. ▪ Ask, what would be your priority be during cold ops? What information would you get? What would your game plan be? ▪ Show Darkstar making inappropriate comms (provides information that flight lead should know.) Ask, why is this a problem?	SA DP&C	Guys that do cold ops well build a mental geometry about what's behind them quicker and they come up with a game plan. You got to go, "where are we in relation to each other?" So the typical game plan is once we know we are all cold, say "viper 3 posit." "Viper 3, is at your right 4 o'clock, 7 miles." Once you know that you may sit there and go, "viper 1 is 2 by 2 by gun." or whatever your gas is. So everybody is going to do that. Why is that important, because if I have a high fast flyer, or if I have a hostile group and I got zero missiles and zero missiles or zero 120s, or 2 120s and 1 120, that means I'm not going to turn around and try and shoot those guys because I don't have missiles. Then you want to come up with a picture. Say, "Darkstar, Viper 1, picture." "Viper 1, picture, two groups, azimuth. North group bullseye x-y-z hostile, South group x-y-z hostile" "Darkstar, Viper 1, BRAA to north group." (BRAA is bearing, range, altitude, aspect) "BRAA from viper 3 to south group." Then, basically you come up with a gameplan. "Viper's game plan is viper 3 you're going to delouse north group for viper 1." As soon as you shoot them, turn back cold and run away, and we'll come up with the next game plan."
Ask: You have a tally on a bogey group, but your wingman doesn't. You know he doesn't. Do you continue to the merge? ▪ What if group is aware? ▪ What if group is unaware?	DP&C , SA, L, ET	Is it addressed all the time with the VID thing, that's a tough question. It is probably not addressed as much as it needs to be addressed. If I have tally on those guys, and my wingman doesn't, as long as I know he does not have tally, I can continue on and have fairly decent lethality at the merge. If I go "viper 1 tally, two ship, my nose, 3 nm." Viper 2 does not say anything, which means he doesn't see them. Ill sit there and merge the guy and say "Viper 2, merged hostile." At that point, if he sees me, he should see another guy. Which means I expect the guy I'm merged with to blow up(?). I may not be able to get a missile off, but my wingman, at that point, should be able to go, "Ah ha, I seen him now" and then as soon as we pass, he shoots. And then, we're going to flow to the other guy and kill him. So, one guy should die fairly quickly. Now, if it doesn't happen like that, then I'm going to be in a situation where I'm BFMing, dog fighting, two guys, and I'm just hoping my wingman doesn't get shot. I'm trying to fly his airplane for him. That's an extremely difficult situation.
Ask: Would you go to the merge 2v4/1v2?	DP&C	Your acceptable level of risk is whether I'm going to go to the merge or not. But what is an acceptable merge? If they're totally stupid (the bogeys), if there are two of me, I'll take twice as many of them. If they're aware, though, I'm only taking same numbers. Most guys will brief, "if they're unaware, we'll go one of us, two of them, and one-to-one if they're aware." Say, they're aware if there's an altitude trend towards you, if they spike or they're showing hot aspect. Most guys will define awareness.
Show radar presentations for different	SA	Draw a few pictures, because drawing a few pictures doesn't take a lot of time, and it just reinforces the idea. Sometimes I will draw it for a brand new guy, which I won't really do in

configurations. Ask we have either two ship line abreast or a two ship trail. What is that going to look like on your radar?“		an operational unit. Sit there and go, “we have either two ship line abreast or a two ship trail. What is that going to look like on your radar?“ You may see something like (draw) that versus something like that (draw). **You would do that for a brand new guy?** Yeah, not that we probably don’t need to do more of it, as a whole. Sometimes that is a difficult thing to do.
Plan Elements		
Discuss swapping wingmen	DP&C, MS	It is not like you are going to sit there and go, “if 3 loses radar, I’m going to be talking to you a lot.” I mean, that’s going to be obvious. When you swap wingman, though, people will talk about that. If we lose radar or someone has no missiles or like one element has no missiles or no radar, we will get someone with a radar and missiles in that element. And that is pretty much all that needs to be said.
Sort plan/target plan	SA	Typically, we’ll have a target plan. Most people will always talk target/sort, and put it up some way visually so people will know. So, it may be like 1 or 2: side/side, near/next near, or out of direction. My sort plan may be side/side, near/far, then if we are going to a VID merge, maybe like trailer. That is pretty much is written on the board.
Sort plan/target plan	MS	Sometimes the brief is better. The simpler the plan, the easier it is to execute by everybody. Remember the targeting and sort matrix I drew up there? It should be easily defined. So, if guys are sticking to that, everyone knows if groups are in azimuth, my radar goes here and your radar goes there.
Contact range	DP&C	The hard part is looking on your radar, getting that SA, or listening to comms that maybe you can’t detect that group. That is where the hard part is. In the mission planning part, you’re going to know what your contact range is. That’s going to drive some of your tactics. That’s going to drive shot range, that’s going to drive how far in you might go.
Level of risk	DP&C	**Is that (i.e., level of risk) something you would talk about in preparation or the brief?** Yep, you will know that. In combat, that is told to you. You will know. The General goes, “You will die for your country today no matter what” or “guys, do not die for country today, do not go to merges.” And we know that, and that is part of their mission plan. That is spelled out in special instructions.
Resources spelled out in the ATO	L, ET	And also what if I knew there were surface to air missiles back here that are good. Well maybe I don’t have to accept this anymore, maybe I could go, “I’ve done everything I can, you know. I’m going to exit the fight and you gotta take out the bad guys coming through this area.” So, that’s all part of the game, not the game, the plan. So, it’s all in the air tasking order, I’m talking combat now, things that we are doing right now in various places of the world. You’ll know all the assets that you are dealing with
Define risk area	T&F	Guys that define the risk area have a very good tactics flow. You may go from: skate to short skate to bonsai, based on where the bad guys are showing up.
VID situations	DP&C, ET, L	I think you owe it to yourself to brief it. Most people

		do. Realistically, though, you're going to know a lot more. You're going to know whether that guy's hostile or not. **Should VID be part of a brief?** Let's say you're going to be up there autonomously. Say, AWACS is going to be midnight from here to here, or off station. I have flown missions like that. Then you're going to have to do that (VID). But you are always going to talk about what if you have a bogey group versus a hostile group. You don't ever brief just a bogey group or you don't ever brief just a hostile group.
Ordnance/threats	ET	Knowing the ordnance you have and who you are fighting is all wrapped into the mission planning part.
Define "awareness"	DP&C, ET	Most guys will brief, "if they're unaware, we'll go one of us, two of them, and one-to-one if they're aware." Say, they're aware if there's an altitude trend towards you, if they spike or they're showing hot aspect. Most guys will define awareness.
Leadership		
Directing	MS	Fifty percent of your 4-ship probably won't happen, but I can see one (alibi) happening and then it really depends on who you're flying with--the experience level. You may get a very experienced wingman on 1's wing, then you go "2 and 4 you'll have to swap," and now that guy can control the element.
Planning Strategy		
Simulation/Role-Playing	SA	Sometimes you draw little pictures up. If this is a good way to do this let me know, if it's not then I can change it. I'll draw pictures up and go, "Okay, if we see a two-ship line abreast, what's the sort going to be?" And you just talked about your sort matrix—side/side, near/far. So, where's sort the going to be to? And you look right at him. And he goes, "Okay my sorts going to be there." And you go "Very good."
Visualization	DP&C	Being at Luke, …I'll draw a picture up of the radar and I'll go, "when I tell you when to sort, anticipate it is going to be no later than 15 nautical miles and this is about where it is going to be. Remember we're going to be checked off to one side" so I draw a little picture on how to do that. As you get more experienced, you shouldn't really have to say that. I mean as long as you have the standard sorting plan, "our sort today: side to side, near far, or unless it is a lead-trail then I will get the trailer and you get the leader." And that is pretty much standard throughout most communities.
	SA, MS	Typically, we'll have a target plan. Most people will always talk target/sort, and put it up some way visually so people will know. So, it may be like 1 or 2: side/side, near/next near, or out of direction. My sort plan may be side/side, near/far, then if we are going to a VID merge, maybe like trailer. That is pretty much is written on the board.
	SA, MS	Just go over the comm. It is always important to really pack the comm. Draw a few pictures, because drawing a few pictures doesn't take a lot of time, and it just reinforces the idea. Sometimes I will draw it for a brand new guy, which I won't really do in an operational unit. Sit there and go, "we have either two ship line abreast or a two ship trail. What is that going to look like on your radar?" You may see something like (draw) that versus something like that (draw). **You would**

		do that for a brand new guy? Yeah, not that we probably don't need to do more of it, as a whole. Sometimes that is a difficult thing to do.
	SA	Don't count numbers and, whenever you brief, it should be generic. It is 2 v x, or 4 v x, or 8 v x. Don't sit there and go, "Today, we're doing 2 v 2" so you only draw two players up there the entire time. …When you talk about your bogey game plan, and you have a hostile-bogey group, well you don't want to say, I shot one hostile and I know he's dead. Now I'm going to go to the bogey group. There's only one guy there. You want to keep practicing what you're going to be doing. So, I think most guys are pretty good about keeping it 2 v x. I'm not going to draw on the board this one guy. When I talk about a bogey game plan, I want to go up to about four aircraft. I don't want to go to the merge if it's more than that. It's unacceptable.
Team configurations	L, MS	Teams. In combat you're going to stick inexperience with experience, and so forth. So, if you have an inexperienced flight lead, you'll have an experienced wingman.
	L, MS	But combat, they'll take a look at who's flying with who and then they will appropriately put the right people together
	SA	*Flying with same team member; shared SA*. Even in Red Flag, you'll have a crew you that you fly with pretty much the whole week. When you're with people over a series of days and missions, you all start thinking "I know what Odie's thinking"… you can already tell what's going to happen. That makes it pretty nice.
Standardization	SA, MS	I'll draw up a…Being at Luke, …I'll draw a picture up of the radar and I'll go, "when I tell you when to sort, anticipate it is going to be no later than 15 nautical miles and this is about where it is going to be. Remember we're going to be checked off to one side" so I draw a little picture on how to do that. As you get more experienced, you shouldn't really have to say that. I mean as long as you have the standard sorting plan, "our sort today: side to side, near far, or unless it is a lead-trail then I will get the trailer and you get the leader." And that is pretty much standard throughout most communities.
Define Risk Area	T&F	Guys that define the risk area have a very good tactics flow. You may go from: skate to short skate to bonsai, based on where the bad guys are showing up.
Know team member capabilities and limitations	L, MS	Know his (AWACS') limitations, and they go, "what are your limitations today?" Well, I have a hard time seeing below this area. So, you need to know that because you may dedicate somebody; "hey when we look back around, you look low with the fighter radar versus me looking at… So it does, if you talk to them I think they need to know their limitations, maybe comm. limitations. If you can't get a declaration to shoot somebody because you are flying at 8 thousand feet but …15 thousand feet I could have hurt them. Maybe knowing that is helpful.
Address Cold Ops procedures.	DP&C, SA	This is what you say—we're going to get our posit down, then you give a comm example, then you do a skate check, and give an example, then we're going to do a picture, and give an example, then I'm going to maybe ask for BRAA so I can figure out where are they exactly behind me, how far,

		altitude. And that will help us formulate a game plan. A poor brief won't address cold ops or they build little errors into their plan because they've never been faced with that situation. Or some guys will say, I don't want a picture, I want everything in BRAA.
Execution Challenges		
Communication	SA	(When switching wingmen.) There may be some comm issues as far as using the wrong call sign…the guy needs to make a mental switch from okay now I am number 4 versus 2 or what ever.
	SA	It all comes down to comm. And it's easy to say comm. Communications today is 3-1 standard, which everyone should know. There is a lead group, trail group, north group, south group. There is a leader, there is a trailer in the group. So, one of you can be so clueless that he hasn't been listening or doesn't have the radar mech to know who the leader and trailer is, Or, two, he just says the wrong thing because of a brain fart. Now he will be sitting there not really knowing. What that may mean is that if you think that he has sorted on the leader, okay, which is two airplanes, one or two miles apart. He says he is sorted on the leader but he really sorted to the trailer. Okay, he may bring the radar into the trailer, what about if the leader goes like this (splits). Now he goes away. Because I depend on him to tell me what is going on with certain individuals. Maybe they went like this and started splitting and I didn't know that because all of our radar went with this one guy. Obviously that is a problem because we have no SA on that free fighter. That's not good. So, it does come down to communication
	SA	So, I would expect him to call "lock, viper 2 lock," and we'll probably read a bullseye position. That way I can move my cursors and go, "viper 2 you are sorted, …" So, through communications that's the only way I know who you really have, unless you have SADL, SADL's great!
	SA	And that is exactly right. A lot of time I will sit there, if I hear "viper 2 sorted" then that means it's in accordance with the plan. He doesn't know who he has I want to hear "viper 2 locked " because that means he doesn't who he has or he's unsure. It wouldn't hurt my feelings either if he said "viper 2 sorted southern" because I go, he is where he is supposed to be. Because if I heard him say "viper 2 sorted northern" I'd go he's on the wrong guy.
	SA	It really happens a lot in cold ops, too. You've seen that where the vipers are running away and there's guys chasing? That is where the comm nightmare starts.
Execution Strategies		
Communication Skills (Obtaining and Sending)	SA	**What can be done about Targeting the same group?** Listening and comm. And saying the right thing at the right time. The comm. ball is between GCI, viper 1, and viper 3. "Viper 2, when we target you into a group, I want to hear "targeted," and I want to hear what fox is coming off your rail and who you have a fox on and I want to hear crank direction." There is a comm ball and comm cadance, so when I hear a guy go, "Viper 2 targeted," and I know by looking that

		he should be shooting based on range, and I hear "viper 2, fox 3 north group, northern," I go, alright. (then) everything's quiet, excellent. See, you're following comm cadance. But if I go, "Viper 2 you're sorted," boom, that interjected a radio call where viper 3 may be trying to shoot.
	SA, T&F	Don't have comms going to more than two people. Okay. "Viper 1 is going to delouse viper 3. Viper 3 you delouse viper 1. Viper 1 in, viper 3 in." You have comm trying to go to two different guys at the same time.
Quitting a plan	DP&C, SA	*When going to the merge.* Sometimes you may turn away and say I can't accept this. My team does not have enough SA to go to the merge**.** One of the most important things to do when you go to the merge is to get the tally ho on the whole thing**.** It does not make me feel good to know I just have tally on one in a two ship, or, even worse, a four ship. If I'm only seeing one of the guys I want to attack, then jeez!. I want to hear from my wingman a tally, and who he's tally'd to, so we can go in with as much SA possible.
Obtain information on leading edge of threat group(s)	DP&C, SA	Or some guys will say, I don't want a picture, I want everything in BRAA. Some guys want the whole picture. I just want to know about the leading edge. I want to kill him (leading edge), run away, and worry about the other guys later. Some guys want the whole picture. Well, they'll rapidly understand why that's not good when they turn back against a five group.
Use other team member's radar	DP&C, SA, MS	I'm using your radar. I'll make the tactical decision but I am using information that I listen to often, what you're saying to make my decisions on.
Change Element Composition	MS, L	If we lose radar or someone has no missiles or like one element has no missiles or no radar, we will get someone with a radar and missiles in that element. And that is pretty much all that needs to be said.
Use Level of Risk to Support Decision Making	DP&C	Your whole tactic is based on what the level of risk is. If the level of risk is low and merges are not acceptable you will not go to the merge. I.e., if it's a bogey group, ideally you have to go down or VID these guys. Are you going to accept that merge or not. Well, low risk, do not go to a merge, it's like, *no*. And usually that decision is made up a lot higher. But if I am protecting this AWACS, or this base, or whatever, I may sit there and go, "out here, I may not accept the merge," but as we get closer I go, "I gotta do it, I gotta accept this merge now".
Use Decision Points	DP&C	You can base your decision on, I'm in this area, I have to go to the merge. Some people may not make a definitive thing like this and go, "well if you pump once you come back …" and now we're being squeegeed in the corner. You know you need to quit and fight with everything he has. I like the definition of a range or whatever it gives you something that is right there not going, "well I'm not really in threat."
Use Cold Ops	DP&C, SA	Guys that do cold ops well build a mental geometry about what's behind them quicker and they come up with a game plan. You got to go, "where are we in relation to each other?" So the typical game plan is once we know we are all cold, say "viper 3 posit." "Viper 3, is at your right 4 o'clock, 7 miles." Once you know that you may sit there and go, "viper

		1 is 2 by 2 by gun." or whatever your gas is. So everybody is going to do that. Why is that important, because if I have a high fast flyer, or if I have a hostile group and I got zero missiles and zero missiles or zero 120s, or 2 120s and 1 120, that means I'm not going to turn around and try and shoot those guys because I don't have missiles. Then you want to come up with a picture. Say, "Darkstar, Viper 1, picture." "Viper 1, picture, two groups, azimuth. North group bullseye x-y-z hostile, South group x-y-z hostile" "Darkstar, Viper 1, BRAA to north group." (BRAA is bearing, range, altitude, aspect) "BRAA from viper 3 to south group." Then, basically you come up with a gameplan. "Viper's game plan is viper 3 you're going to delouse north group for viper 1." As soon as you shoot them, turn back cold and run away, and we'll come up with the next game plan."
Stick to plan	SA, MS	The simpler the plan, the easier it is to execute by everybody. Remember the targeting and sort matrix I drew up there? It should be easily defined. So, if guys are sticking to that, everyone knows if groups are in azimuth, my radar goes here and your radar goes there. That's pretty simple. The hard part is looking on your radar, getting that SA, or listening to comms that maybe you can't detect that group. That is where the hard part is. In the mission planning part, you're going to know what your contact range is. That's going to drive some of your tactics. That's going to drive shot range, that's going to drive how far in you might go.
Knowledge that Supports Execution & Planning		
Execution Templates	L	Fifty percent of your 4-ship probably won't happen, but I can see one (alibi) happening and then it really depends on who you're flying with--the experience level
Timeline Awareness and Own Capabilities and Limitations	L, DP&C	**I've heard that from the Army, too, about not being overly committed to your plan. That's hard to do--back away from a plan.** It is hard. You see these airplanes and they have no clue we're there. But you still can't shoot them until you see what they are. So here you go. You have a great position, but you don't have all the tally hos, but you go in there. And, they go, "someone is going to attack me," and they turn, and the one you don't see is going to kill you. Even though up until the time they turned you were in an incredibly offensive position. All of the sudden the hunter became the hunted.
Knowledge of Element	MS, L	If you have two bad radars, now you may have to start swapping within the elements. Fifty percent of your 4-ship probably won't happen, but I can see one (alibi) happening and then it really depends on who you're flying with--the experience level. You may get a very experienced wingman on 1's wing, then you go "2 and 4 you'll have to swap," and now that guy can control the element.
	SA	(common ground) Even in Red Flag, you'll have a crew you that you fly with pretty much the whole week. When you're with people over a series of days and missions, you all start thinking, "I know what Odie's thinking"… you can already tell

		what's going to happen. That makes it pretty nice.
Knowledge of Distributed Teams Capabilities	MS, DP&C	**Part of the decision-making would be to retrograde the asset you are protecting?** Yes. There may be a range. If it is AWACS, he'll retrograde himself. He'll slide or at least, say, "Dude, I'm out of here man." Wooh, he's gone. "Thanks for helping me out, by the way." So, you can go ahead and direct people, slide this way or move this way. That is a higher level of understanding than I know you are going to find most in Viper communities.
	L, DP&C, MS	Know his limitations, and they go, "what are your limitations today?" Well, I have a hard time seeing below this area. So, you need to know that because you may dedicate somebody; "hey when we look back around, you look low with the fighter radar versus me looking at… So it does, if you talk to them I think they need to know their limitations, maybe comm. limitations. If you can't get a declaration to shoot somebody because you are flying at 8 thousand feet but …15 thousand feet I could have hurt them. Maybe knowing that is helpful.
	SA	This is what you say—we're going to get our posit down, then you give a comm example, then you do a skate check, and give an example, then we're going to do a picture, and give an example, then I'm going to maybe ask for BRAA so I can figure out where are they exactly behind me, how far, altitude. And that will help us formulate a game plan. Dark star, AWACS is listening, so they are part of it. **Do you want them to be quiet during this unless there's something you definitely should know?** Yes, for example, I know I left at 12 miles. If they are not puncturing our threat range, I don't need to hear about that. Or if you called the threat and I turned cold, I don't need to hear about that again. I know they're back there. So don't be saying "Threat, BRAA, bullseye… " I know they're back there. I'm running away from them. So tell me something I don't know. Keep quiet. So get BRAA to that group when you're ready to listen.
Blue on Blue Situations	SA, T&F	When I go to the merge and my wingman has no clue. That is most likely where a frat will happen. I would say VID merges are the worst ones. When you go into that merge with low SA, and you don't kill someone right off the get go, you end up turning around. As soon as that thing turns, your whole SA starts shrinking.
When to go to the merge	DP&C, ET	Your acceptable level of risk is whether I'm going to go to the merge or not. But what is an acceptable merge? If they're totally stupid (the bogeys), if there are two of me, I'll take twice as many of them. If they're aware, though, I'm only taking same numbers.

APPENDIX C

Background Interview Data
Obtained from One Air Combat SME

Notes. Knowledge category codes are defined in Table 3. Interview content represented in bold font are interviewer verbalizations.

Description of Interview Content	Knowledge Categories	Interview Content
What-If Examples		
Present a situation in a grinder in which #2 did not follow the game plan and forces a VID situation.	SA, MS, DP&C	That's what I'm talking about, where he didn't follow the game plan and if he doesn't say anything and all of a sudden, me as number one come wheeling around, and now I'm going, "hey, what is this?" Now I may not be able to employ the BVR, because now I got friendlies and hostiles all mixed up in the same group, then that's bad. **So how would in a situation like that, if you've been in one, what does everybody do to get, you know, what do they do?** Ah well, if they're mixed up then three and four better run like, excuse me, run like hell and then now I'm going to have to really use some com to decipher who is who, and sometimes that can happen, sometimes it can't happen and it may force a visual identification problem. So, now your whole focus is you've got to have your guys survive, although you'd rather club them over the head with a club. But, now you're going to have to save them totally come off your game plan, you have to forget about everything else that's going on and you're going to have to go and get these guys off of number three and four.
Present tactical situations and ask trainees how to position themselves to be in an advantageous situation	DP&C, T&F, SA	Well, interpreting the radar in where do I need to flow my flight. To put myself in, in an advantageous situation. We always see problems with groups doing that, usually they can target correctly, their shot doctrine is usually pretty decent. I think putting their flight, though, in a more advantageous position is sometimes a little bit of a limiting factor, so they start off from a position of disadvantage, whereas if they would have flowed their flight a little better then they would have been in a position of advantage.
Plan Elements		
Discuss what to do if groups are maneuvering	ET, DP&C	Yeah, you'll talk about that, a lot of times you'll sit there and go, okay if groups are maneuvering, we are just going to turn around, run away and let it settle out. Because again, you know, if they're doing exploding cantaloupe they can't kill you and they can't kill whatever they wanted to kill, because they are doing all those funky maneuvering or whatever, so eventually they'll have to come back hot, and settle down…
Blue-on-blue	DP&C, SA	You talk about getting good targeting, sorting and you talk about, you know, for shot doctrine, you always have to have an ID and a clear field of fire, or clear avenue of fire. Then, that's always brought up pretty much, because the guy

		hitting the tickle button has to know, no kidding, if that's a bad guy.
Commit criterion	DP&C	...whenever you have a DCA mission anyway, you're going to have to figure out what's your criteria for your commit. And part of that's going be what ordinance you're carrying and what you're really protecting. Because it may be a DCA lane defense mission or a DCA point defense. I may be given a block that's, I don't know, say, fifty miles wide and a hundred miles deep, or whatever… So, first you've got to figure out, you know, the kind of air you're playing in and what kind of ordinance you're to be carrying, because that'll have some effect on what you're dong. And also, the political situation. You take a look at, well, what's out commit criteria, as far as you know? Is it only when they come across the border? Or, if they commit a hostile act anywhere? Is that clearance for us to engage? And things like that. So that's kind of first, first, I guess, decision point, is okay, what's really going on in the big picture.
Big picture	DP&C	So, first you've got to figure out, you know, the kind of air you're playing in and what kind of ordinance you're to be carrying, because that'll have some effect on what you're dong. And also, the political situation. You take a look at, well, what's out commit criteria, as far as you know? Is it only when they come across the border? Or, if they commit a hostile act anywhere? Is that clearance for us to engage? And things like that. So that's kind of first, first, I guess, decision point, is okay, what's really going on in the big picture.
Contingencies	DP&C	One thing contingencies is, right off the bat, is gas. You've got to worry about, are we going to have a tanker? Maybe the people next door on another lane, they fell out and then you have to start worrying about gas and covering their lane. Another one is, what if AWACs goes midnight and you don't have them anymore. Another one is weather, you know, what are the, the contrail levels, what are the winds and what are the clouds? What if somebody has a problem and they have to go back? So you have to plan for, if I have a four ship, maybe being a three ship. And then what happens if like, you know, number one and number three in particular, what if their radar goes bad. So one of the airplanes has some sort of an aircraft system limitation.
Contingencies -AWACS	DP&C, MS	...let's talk about the AWACS. If, let's say that I have a four ship, well, if we're all going the same way, then eventually in my CAP I'm going to have to turn around and run away, and go away from them for a while. If we don't have AWACS, we may not see something that pops up on the scope, okay, so if I know that I don't have AWACS I may have to adjust the kind of formation that I'm holding my CAP in. So instead of all four of us going down track the same and then turning cold and running away then turning hot and running, I may put two guys going cold while the other two guys are going hot. Now my radars are out there looking, so I always have

		somebody looking down track. Well, it goes back to my tactic of, do I want to employ us as an entire four ship or not. If there's, I may not be able to react quite as fast if I'm broken down into two ships and I want to come out as a four ship. It shouldn't be that much of a limiting factor though, if two ship is running hot they see something, they can always call it out, great, so everybody, even though my radar is not on them and I'm going cold, I know about them, and then what I could do is sit there and go, okay, well, now, I'm going to turn back hot and hey number three I want you to rejoin on me now, so we can go up as a four ship. So, it's not that big of a deal but we can get at least, you know, radars down, some radars down there and then we can come up with a game plan. The biggest thing about no AWACS though, at least for F-16's is that the identification of the bad guys, that's going to be a limiting factor, and I won't go more into that.
Contingencies-radar	DP&C, MS	If the radar goes bad then I may have just lost a lot of my missiles, so you need have a plan. For example if, number three and number four are having problems with their radar, I may want to split my element up so that I have one good radar per element.
AWACS role	MS	... the most successful teams are the ones that keep AWACS in the loop and AWACS keeps them in the loop and there's not too much blabbing going on so, if everybody does what they are supposed to then, then it goes a lot smoother. AWACS is listening for any groups that haven't been targeted and then they'll remind the flight lead, "hey, guys did you forget about this guy." And again, he is part of the team so he's carrying his contracts out also. **Is any of that ever part of the brief or part of the plan, like, just reminding like, the fighter pilots to give the AWACS certain information at a certain time? Or is it, kind of, implicitly, implicit and gained with experience?** No. It should be part of the brief. But, it should be standard. I mean, AWACS has set standards, and if the flight lead wants to change the set standards, then he needs to brief them. The guys that do the best are the ones that have a very good working relationship with the AWACS.
Use of standards	SA	There are always standards. So, if you know that AWACS is operating off of the latest standards and you are operating off of the latest standards, then everything should be good. But, you can always air brief a guy, saying hey I want this, you know, if I call for this, I want this. And that's okay, too. And the guy on the console needs to be flexible in that but, the best thing is to stick with the standards and use them.
Shot doctrine	ET	So, in the merge phase, as far as the pre-planning, what's extremely important is your shot doctrine. And that's going to come off of your pre-planning....If you're seeing them doing some other stuff, you can sit there and go, wow, I'm not going to make it. They're running me out of gas, or they're running me out of missiles, and you can sit there now, change your shot doctrine.
Communications	SA	I go, "Guys, instead of like blabbing all the time just shut up

		and listen," because a lot of times there's a lot of repeat information out there which lowers everybody's situational awareness. The comm time gets very compressed in some situations so, if someone doesn't listen to what someone just said and he has to ask for the same information, we just lost. Plus, the reply of whoever he's asking information for, then we just lost maybe ten seconds of com time. And what happens in that ten seconds if someone needs to make a break call, you know, because somebody that they didn't see all of a sudden popped up at their six o'clock. But someone's blabbing on the radio about something that was already said. So a lot of it is listening and really digesting the information.
Plan and Brief Organization		
Decision sequence	DP&C	So, the first one is what is my mission? Is it DCA lane or DCA point? What kind of ordinance do I have? And how long do I have to be there? At that point, now I'm going to start figuring out, What kind of force do I need to protect that? Can I do it with a two ship? Can I do it with a four ship? Am I going to have to cycle on and off the tanker? Am I going to have to be really careful of the amount of missiles that I'm employing because I don't have enough? Things like that. Now, once I have figured, what's the big picture, then I have to go, okay, where do I want to put my cap in the most advantageous position so I can be in more of a offensive position and cover all the airspace that I need to cover?
Mission phases	DP&C	**Do you plan around those phases?** Yes, we already talked about the cap, and that's going to be based on what am I protecting, and things like that, and also what kind of ordinance I'm carrying. Okay, the commit, we talked a little bit about already. At what point am I going to sit there and go, I need to leave, excuse me, I need to leave this cap and go and engage these people. The merge prep is nothing more than getting my appropriate radars down there to target the threats coming my way. The merge, is BVR is happening at range, so a merge may be nothing more than, now we're starting to employ ordinance on these guys and then we're going to, clean up the merge, see if our missiles take them out. And post-merge is, where am I moving my forces when I come off this engagement? Where am I flowing to? Am I going to flow down to the south to take care of somebody else or to maybe get rejoined with my flight? That's what we're talking about in post-merge.
Variations in Planning and Briefing		
Incorporation of AWACS into plans	SA	It helps them, I mean, it keeps their SA up, because again, they're part of the team, the most successful teams are the ones that keep AWACS in the loop and AWACS keeps them in the loop and there's not too much blabbing going on so, if everybody does what they are supposed to then, then it goes a lot smoother. AWACS is listening for any groups that haven't been targeted and then they'll remind the flight lead, like, hey, guys did you forget about this guy. And

		again, he is part of the team so he's carrying his contracts out also. It should be part of the brief. But, it should be standard... the guys that do the best are the ones that have a very good working relationship with the AWACS.
Leadership		
Directing	SA	If I tell, tell a tactic to my flight, I want them to do that tactic and don't go off the game plan. It's kind of like, you're the quarterback and you're going to tell a guy, look, I want you to run ten yards down the field and then turn to the outside, towards the sideline, I'm going to throw you the ball. So, he runs ten yards and goes, to the inside, it's going to be a messed up play. Well, the same thing happens if there's a breakdown in the game plan. Someone's not executing what they're supposed to do then, all of a sudden, my situational awareness goes down and that's when we potentially have a blue-on -blue problem. So, the guys have to execute the game plan, and other than that, really, the biggest thing about blue-on-blue is when you enter a merge, a visual merge…
Prioritization	L	I always try to give my wingman the easiest thing, and I leave all the hard decisions for myself. So I tell them, "if I tell you to target a group, that group is yours, you own that group, you tell if the group is doing anything." The wingmen that do that, you know, we are a better fighting team; the wingmen that don't do that, then you're, your SA goes down.
Planning Strategies that Support Execution		
Standardization	SA	Well, they should be sticking to the standards. You sometimes go over them. If I knew that everybody in room was totally familiar with standards, I could sit there and go "comm standard," and that is the only thing I have to say. But typically you'll brief a little bit about it, you'll go over some examples and make sure that everybody is on the same sheet of music.
Execution Challenges		
Communication	SA	Let's say that I have a two ship that's going to attack that four ship. Well, the more I know about that group, then the better I'm going to be able to attack it. Let's say that I only send in a two ship though, and all of a sudden, I find myself in and amongst a four ship, then again, that's where, we're going into something that kind of was new to us and we have to be very flexible in a very rapid amount of time and that's again when you're starting to think about the fratricide. A good com would say, "Viper one, group four ship off the container… " You're all on the same sheet of music and now, as you go into this merge, probably good things will happen. But conversely, let's say that the com is terrible. There is starting to be a break down, our situation awareness isn't as high as you go into this merge. And if, all of a sudden, there's a com break down, like a call is not made, like you really killed somebody or, oh, my god, there's four of them not two of them, then all of a sudden again your

		chances for fratricide has gone way up.
	SA	So a lot of it is listening and really digesting the information. That's the hardest part about being in a single seat airplane.
Does not follow game plan	SA	Let's say that my tactic is to leave at range, but I decide I'm not going to do that, I'm going to go closer to this merge. Well, now I may have red airplanes and blue airplanes mixed up. Let's say that was number three and four, and when one and two start looking with their radars, now all of a sudden they have a chocolate mess to deal with, versus where if the guy would have executed the game plan then it would have been a nice picture to deal with. Now I may not be able to employ the BVR, because now I got friendlies and hostiles all mixed up in the same group, then that's bad.
Does not follow game plan	SA	Its kind of assumed that if a guy just trundles into a merge and first off, he could die, and second off if he doesn't die its going to be a chocolate mess. And that's pretty much understood. But it happens because guy goes, "Yeah, I can make it happen I can do it, one more second I can kill these guys," and it doesn't happen, then all of a sudden it's bad.
Keeping SA via comm going into a merge	SA	I think the hardest arena is the visual identification where you've got several entities that you're wading into. So, let's say you're attacking a four ship. It could be either a two ship or a four ship of blue air, but, the bottom line is you have a completely compressed comm, things are happening so quick because you're closing, every three seconds you're closing a mile…A lot of things are happening, so your comm has to be pure because if it's not, then you're not going to hit the merge with the most situational awareness.
Workload during a merge	SA	I'm worried about where my wingman is and I'm worried about what numerous people are doing i.e. like you know the threats. So if I start going in there and all of a sudden they start breaking left and right, and going every which way, then all of a sudden is like…If you don't have identification at that point, it really gets to be messy The bottom line is that when you hit that merge you want to be able to make somebody go away. And then, hopefully maybe even two people go away, and then now, if you took a two ship in, if you had a four, if you were attacking a four ship in, at the merge you made two people go away almost instantaneously now, you know the numbers are a lot easier to deal with.
Identification, communication	SA	Take a look at an F-18, a Fulcrum and a F-16. And sometimes it is extremely difficult to tell who's who. Well, I mean, hopefully you shoot the right person. I mean, that's when com comes in, you may go, Viper Two status, and he may say, hey I'm a little guy going due north. Well if you see two guys and one guy is high and one guy is going due south, you see a little guy going due north you may sit there and go, hey man, my bro is in trouble and you're going to take, kill the other guy, you know, but that's based off of com.
Communication	SA	Typically, BVR, things are fairly quiet till the shots are starting to come. When does it get, you know, it gets

		difficult maybe when the groups start maneuvering and then the comm time will start decreasing because there'll be a lot of people jabbering about what the guys are doing. Hey, the north group is maneuvering, flanking south, you know, so at that point there is some com that will start getting compressed.
High workload situations	SA	I think the hardest the hardest thing that we all do is go to a visual merge against multiple enemies. That is the highest stress level. I would say the second highest stress level is when we're running away and now we have to build this mental picture of what's happening behind us, and guys did not blow up like they're supposed to blow up. That's a fairly high stress level because your SA is totally based on com, now between you and AWACS and your radar works is going to have to be very good, particularly if we have guys that are chasing me out. And maybe, the third would be when I'm taking shots at range and now the groups start maneuvering and, you know, they're not doing simple maneuvers, we're talking the exploding cantaloupe. That's a fairly high level of stress area, too. Now, you can turn around with a little bit more situational awareness and you got range to deal with it. But if you sit there and see this exploding cantaloupe going on, and you just keep driving at it, and you are not good going at everybody in that whole exploding cantaloupe targeted…
Communication	SA	**Does take some experience to get used to using all the right terminology?** Yeah. Particularly in a high stress situation. **You forget it then and have to revert to longer phrases?** We call it Navy talk, no. No, you know, I use that affectionately. No, that's exactly the case. Communication between two people is relatively simple when you're sitting there, because you've got the facial expressions, the hand gestures and all that stuff. But now when you're flying an airplane, you don't see of that and everything that you gain of situational awareness from that guy is pretty much through communication. If your definition is different than somebody else's definition then obviously that causes problems.
Radar mechanics	T&F, SA	Well, interpreting the radar in where do I need to flow my flight. To put myself in an advantageous situation. We always see problems with groups doing that. Usually they can target correctly, their shot doctrine is usually pretty decent. I think putting their flight, though, in a more advantageous position is sometimes a little bit of a limiting factor, so they start off from a position of disadvantage, whereas if they would have flowed their flight a little better then they would have been in a position of advantage. I mean, the radar will display, you know, where things are in raw form and then you've got to, you have to sit there and go, okay, now what do I do with that information?
Prioritization	SA	He may miss-prioritize. When you are so worried about getting the shots off the jet that he is dragging himself into an area where he could be shot. So, I would say that would be a miss-prioritization and he's not using the information on

		his radar to prioritize. Let's say we go back to our tactics again, or my game plan, let's say that I want my flight to never go inside a certain range. This guy is, you know, he's out there and he doesn't want to fail and he wants to get those shots in that group and he presses his two ship into that threat. Well it was a miss-prioritization because he's trying to get the shots off but he's screwing up the game plan, you know, trying to do that.
Execution Strategies		
Stick to the game plan	SA	If I tell a tactic to my flight, I want them to do that tactic and don't go off the game plan. It's kind of like, you're the quarterback and you're going to tell a guy, look, I want you to run ten yards down the field and then turn to the outside, towards the sideline, I'm going to throw you the ball. So, he runs ten yards and goes, to the inside, it's going to be a messed up play. Well, the same thing happens if there's a breakdown in the game plan. Someone's not executing what they're supposed to do then, all of a sudden, my situational awareness goes down and that's when we potentially have a blue-on -blue problem. So, the guys have to execute the game plan, and other than that, really, the biggest thing about blue-on-blue is when you enter a merge, a visual merge…
Use wingmen	L,	I always try to give my wingman the easiest thing, and I leave all the hard decisions for myself. So I tell them, "look if I tell you to target a group that group is yours, you own that group, you tell if the group is doing anything." The wingmen that do that, you know, we are a better fighting team, the wingmen that don't do that, then your SA goes down. Anyway, so I always give my wingman the easiest problem, but, no kidding, he has to stick to the contract that we brief to, like, hey, if that guy maneuvers and trashes your shot or he maneuvers, I need to know about it, you know?
Comm	DP&C, SA	Well, I mean, hopefully you shoot the right person. I mean, that's when com comes in, you may go, "Viper 2, status," and he may say, "I'm a little guy going due north." Well if you see two guys and one guy is high and one guy is going due south, you see a little guy going due north you may sit there and go, hey man, my bro is in trouble and you're going to take, kill the other guy, you know, but that's based off of com.
	SA	Good communication will keep you out of a problem area, and as long as guys are disciplined with your shots, then you should be good to go. But if guys aren't disciplined with their shots and the communication is poor, that that's what's going to happen, someone's going to get shot by their own guy.
Comm priorities	SA	That's when you have com priorities. Again, if they turn sideways where they have gone away from you. They've turned away and they are starting to run, com goes up, com time opens up a little bit because yeah they've maneuvered but they are going away, they can't kill us now. So once the

		initial word happens, like Viper two north group maneuver south. But if you can get groups going sideways or dragging away from you, at least your range isn't collapsing toward that group. The com time is a little bit more available because you have range on your side versus if something is happening and you're closing in on the group that's, that's when you start getting maxed out.
Run away for exploding cantaloupe	DP&C, T&F	If I see an exploding cantaloupe, I try to run away because, eventually, if they want to kill me they're going have to come back towards me. You'll talk about that, a lot of times you'll sit there and go, okay if groups are maneuvering, we are just going to turn around, run away and let it settle out. Because if they're doing exploding cantaloupe, they can't kill you and they can't kill whatever they wanted to kill, because they are doing all that funky maneuvering. So eventually they'll have to come back hot, and settle down…
Maintain contracts	SA, MS	**Is there anything you can do to minimize the likelihood of a blue-on-blue situation? Y**ou follow the ACM rules. Who's the engaged fighter? Who's supporting fighter? Or, or I guess probably the biggest one is, who's the engaged element? Let's say we have a four ship again and we're going against a bogie group that we have to visually identify. Well, everybody just can't be jumping in there and trying to shoot people, because what happens is, if you don't have very good com, all of a sudden, you might be getting shot by one of your own guys. So, that's why it is very important for people to uphold the contracts of who's engaged and who's supporting.
Preventing blue on blue	SA	There's three kinds of situational awareness. Positional situational awareness of guys in my flight. One is, I see them on my radar. Two is that, through communication, they tell me where they are, and I am able to correlate that and go, yep, that's where they are, okay? Or, three, there are some data link systems that will put a visual picture in your aircraft of where the other guys are. They're all a combination. It's nice when I have my, if all of our, you guys know what bull's eye is? Okay. I'm talking from the same known point, so let's call that bull's eye, all right? Then if my number three man, let's say I don't see him, I don't visually look out my window and see them because maybe he's split off, but he goes, I am bull's eye XYZ, okay, so he says his position off of bull's eye, well if I can correlate that on my radar or I can correlate that on something else, then that is great, because now I have two sources and it makes my job easier. I feel a little better about it. If you're saying he's somewhere, and I can't correlate it, then it kind of lowers my SA a little bit, I mean, I would like to be able to correlate it from a couple different sources. Particularly if one isn't operating correctly, whether it be radar or my data link, or we're not, we're getting com jammed and I'm not getting a lot of com.
2-ship vs 4-ship	DP&C	Let's say you have a four ship that's supposed to be on

		station for two hours and you are going to start running out of gas, so what happens is you're cycling in two ship, your wingman is going to be, a primary targetter, but, if I have two wing, if I have the whole force up there, then I may opt to do things a little different.
Use of wingman's radar	DP&C, SA	We're both out there sweeping, and now we need to detect something. If we have AWACS or ground patrol intercept radar, it make it a little bit nicer is, assuming they have a good picture of all the operating areas, there are no shadows, there're not a lot of mountains where maybe bad guys could hide behind, or whatever. But the bottom line is we'll get a little bit of information from them and using that information and our radar, now we can target the appropriate person. I mean, like I said before, I'd rather use my wingman's radar at range to target in there. Why? Because as soon as you take a radar lock, you're situational awareness goes down a little bit because of other radar issues. Bottom line is, you want to use his radar to start shooting people, or get more high fidelity information and then you should be sweeping, you know, so you can have a big picture of what's going on. The flight leader's trying to keep the big picture.
Use of commit criteria	DP&C	You want to engage them far enough away so, if for some reason they don't blow up, then you still have some time to take care of them. So you want to be able to get them right when they're meet commit criteria, you don't want them to wait back too far where you have to start really worrying about, you know, if I don't this right the first time, we're screwed. The bottom line is, regardless of what it is, whether it's hostile, spades or bogey, you're going to commit out and then, now, knowing what they are helps me because it'll help my intercept geometry. Do I go low? Do I go high? Things like that.
Position CAP	SA	If you have a couple people in a rectangular room and you know, you had people lined up along the, you know, the one end of the room, and they were supposed to run to the other end of the room, but you were protecting the other end of the room and you had to tag each person, you probably wouldn't want to be against one wall, you know, you probably want to be in the middle so you can go half way with each, right? That's the same thing for an airplane, is I have to position my cap in a place where I can cover my entire area that I'm responsible for.
Knowledge that Supports Execution		
Comms indicate SA level, how mission is going	SA	Because you're doing multitasks, the first thing that drops out… You can tell, when someone's SA is going down. com starts going to shit. **Do they talk too much or not enough?** Well, they'll do both, I mean, sometimes they'll say nothing when they're supposed to be saying something and other times they'll be spouting off about stuff that's not important and they're totally miss-prioritizing.
	SA	Guys know that if com is just ticking, I'm sorted here, yeah you're sorted there, oh tally four, tally four, you know, as

		you're coming to the merge, you just know by com, things are going your way. But if you're not hearing that com, that's when you sit there going, uh-uh, you know, things aren't going my way, I really got to be careful.
	SA	The best missions are the ones that execute the game plans and have very good com. Not too much com, not too little com. Com when when it's required.
Visual merge	SA, L	But, if you went to an F-16 and F-18 or an F-18 and F-15 or Fulcrum, then, all of a sudden it gets a just a little more difficult. So, whenever there's a visual merge, the hair on the back of my cranium stands up because that's when things can happen.
ACM rules	SA	Well, you just, everybody just can't be like, jumping in there and trying to, you know, shoot people, because what happens, always, that I've seen, well, not always but, most of the time is, if you don't have very good com, all of a sudden, you might be getting shot by one of your own guys. So, that's why it is very important for people, again, to uphold the contracts of who's engaged and who's supporting.
Timeline Awareness and Own Capabilities and Limitations (i.e., Missile Load, Gas, Radar)	T&F	But if you wanted to break down, a air threat coming into our DCA lane, you've got your cap phase, you've got your commit phase, you've got your merge preparation phase and your merge phase and post-merge The commit, we talked a little bit about already. At what point am I going to sit there and go, I need to leave, excuse me, I need to leave this cap and go and engage these people. The merge prep is nothing more than getting my appropriate radars down there to target the, the threats coming my way. The merge, is BVR is happening at range, so a merge may be nothing more than, now we're starting to employ ordinance on these guys and then we're going to, you know, clean up the merge, see if our missiles take them out. And post-merge is, where am I moving my forces when I come off this engagement? Where am I flowing to? Am I going to flow down to the south to take care of somebody else or to maybe get rejoined with my flight? That's what we're talking about in post-merge.
Knowledge of Element (i.e., Load-Out, Gas, Capabilities and Limitations, Roles and Responsibilities)	DP&C	...whenever you have a DCA mission anyway, you're going to have to figure out what's your criteria for your commit. And part of that's going be what ordinance you're carrying and what you're really protecting. Because it may be a DCA lane defense mission or a DCA point defense. I may be given a block that's, I don't know, say, fifty miles wide and a hundred miles deep, or whatever… So, first you've got to figure out the kind of air you're playing in and what kind of ordinance you're to be carrying, because that'll have some effect on what you're dong. And also, the political situation. You take a look at what's out commit criteria. Is it only when they come across the border? Or, if they commit a hostile act anywhere? Is that clearance for us to engage? And things like that. So that's kind of first, first, I guess, decision point, is okay, what's really going on in the big picture.

Load out, play time	DP&C, T&F	You're going to use your wingmen and pretty much get their radars into the groups. And if they're declared hostile, then you're going to start shooting as soon as you're in a web. When you shoot depends on many missiles you have and how long you have to be on station. Obviously, if you have to be on station for five hours, your shot doctrine's going to be based that. But the bottom line is that, at some point, you're going to start deploying ordinance if you have a hostile declaration, and you're going to do that for, you know, at range.
Wingman responsibilities	T&F, MS	So, to answer your question, it's pretty much standard, I mean, basically, my wingman's going take the first hostile, the nearest hostile group and then, after that, going to take what we call spades groups, which means that, you know, if we know that a group isn't squawking the right kind of codes, we're going to see if we can update them to a hostile by using his radar and lastly, I'll put my wingman on bogie groups, but it depends on if you're using a grinder or well tactic…
Contracts	MS	Let's take an easy problem. There're just two of us out there. And my contract is that I can search the low area, so I'm sweeping and I'm looking from the surface up to whatever altitude, and then my wingman, he's going to look with a little bit of overlap on my radar coverage, he going to look, you know, say fifteen thousand feet and up. We both have a contract to uphold, because if I look high and he looks high, then maybe someone can sneak in down low.
Mission timeline and decisions	DP&C, T&F	Your commit criteria may be something like, if this guy is plus or minus sixty degrees heading of 0-9-0 so if he is going like 0-3-0 to 1-2-0 and he's crossing that line, then he may be committed upon. That's kind of generic, but that would meet what we call commit criteria. Now, whether he's a hostile, spades or bogie is going to influence my geometry for intercept. Do I go high? Do I go low? Do I offset one way or the other? So, your commit criteria is pretty much you're going to meet that and hopefully, you're going to have declaration so it'll optimize, you know, your geometry to get these guys. As soon as we know what is coming at us, like, what kind of picture is it? Are they groups in range? Are they groups in azimuth? How wide, how deep? Then we can figure out our game plan. If I have a four ship, I may not want to send all my forces forward immediately, I may want to send a two ship to kind of probe a little bit before I send all my forces, so, like I said, now the tactic part comes in, is okay, these groups are meeting commit criteria, What, what is really coming across the line? Like I said, is it groups in range? Groups in azimuth? Is it a bogie group or hostile group, and I choose my tactic based on what's coming across the line. We know what the picture's coming out of, so you have this mental picture, let's just say it's two group range. I can commit all four maybe, okay, so we all, at that point commit out, we're starting to push towards the threat. Now, I'm sitting there going, okay, two, target this group. So he targets it. Now, if it's a hostile, then we go right from the

		merge prep right into the merge phase, where now we start to employ ordinance. So, as long as they're hostile, you go right to the employ ordinance phase, and now, he tells me when he employs ordinance and I maneuver my flight to a better position. So right there, you've gone from the commit to the merge prep, we're now throwing radars in there…As long as he's hostile, yeah, now shots will come off the rail. And then we kind of go into post-merge because now I'm maneuvering my flight and I have to wait and see how my missiles are doing. And then I may leave or may go clean up the merge. Whether you leave or clean up--that's all lumped into that post-merge phase because you're making a decision based on what just happened, okay? Okay, so they're coming across the line, there're four of them, and I have a couple guys taking missile shots into that group, okay? Well, how far do I need to continue to go, because I'd rather not go and, when I say merge, I mean, like no kidding, if a VID, a visual identification, I don't want to have to fly right by them and sit there and go, oh, that was a fulcrum. I'd rather blow them up far away. Not very chivalrous, but that's the way war is now. If I get the shots off, now I have to decide, do I want to follow the shots up? I mean, no kidding, to see if these guys die, or do I just want to leave? Let's say I have AWACS, well, if I turn my tail and run away, okay, are my missiles are killing them, maybe or maybe not. Maybe a missile fin came off from a missile, maybe the fuse didn't work, you know, maybe well, you know, if there's instead of two guys, there's really four guys I didn't know about and neither did anybody else... So, there's a lot of decisions that you have to, like you said, you have to make in regards to, okay, do I feel like I need to go and watch this whole thing explode, or can I just leave and pick it up later?
Knowledge of Distributed Teams Capabilities (i.e., GCI, F-18s, F-5s)	DP&C, T&F, SA	Let's talk about the AWACS. Let's say I have a four ship. If we're all going the same way, then eventually in my CAP I'm going to have to turn around and run away, and go away from them for a while. If we don't have AWACS, we may not see something that pops up on the scope. So if I know that I don't have AWACS, I may have to adjust the kind of formation that I'm holding my CAP in. So instead of maybe being all four of us going down track the same and then turning cold and running away then turning hot and running, you know, I may put two guys going cold while the other two guys are going hot. Now my radars are out there looking, so I always have somebody looking down track.
2-ship versus 4-ship tactics	DP&C, T&F, SA	Well, it goes back to my tactic of, do I want to employ us as an entire four ship or not. If there's, I may not be able to react quite as fast if I'm broken down into two ships and I want to come out as a four ship. It shouldn't be that much of a limiting factor though, if two ship is running hot they see something, they can always call it out, great, so everybody, even though my radar is not on them and I'm going cold, I know about them, and then what I could do is sit there and

		go, okay, well, now, I'm going to turn back hot and hey number three I want you to rejoin on me now, so we can go up as a four ship. So, it's not that big of a deal but we can get at least, you know, radars down, some radars down there and then we can come up with a game plan. The biggest thing about no AWACS though, at least for F-16's is that the identification of the bad guys, that's going to be a limiting factor, and I won't go more into that.
AWACS	SA, MS	Number ten is what ways are you supported by the AWACS? I mean, obviously they are a great part of the team because they are basically like a super wingman. The only thing is they can't kill things so, that's why, you know, they need us. But AWACS will be able to help us out by maybe breaking out how may people are really coming across, and what kind of people are they, and are they hostiles, spades or boogie, because again we can't employ ordinance unless they're hostile. Plus, because they are such a big airplane, they can see further than the radars that we have, so they can give situational awareness ahead of what our radars would tell us. It's kind of like if you could see long range driving down the freeway and you see someone swerving in your lane, you can get out of the way, right? Well, now say you put a blindfold on you and the guy swerves into you lane and then now all of a sudden take it off of you, well, your reaction time is limited. So that's exactly what AWACS does for us, they give that long range look that we can set up our tactic and we can be in a more advantageous position to kill them, to kill the bad guys.
AWACS Commit authority	DP&C	Some leads will allow them to call the commit. If we're protecting a high value asset, they may have it within the rules of engagement that they are the commit authority, so it depends on how the rules of engagement are, but typically fighters have the commit call, AWACS can recommend it.
Enemy Threat Capabilities (i.e., SAs, Intel Brief)	DP&C, ET	Let's say that I have to protect a fifty mile wide lane for three hours, and they've been doing a lot of probing tactics, like they come flying in, but then they turn around and run. Well, it's probably better for me not to go just wasting my missiles and not getting anything out of it. If they're defeating all of my missiles because they keep running away, then, if I don't know that, I'm silly and if I keep shooting at stuff like that that's silly, because pretty soon, I'll be out of, out of weapons and then I'm worthless.
Shot doctrine	T&F, DP&C, ET	Remember talking about, what have we been seeing these guys do? What has intel told us, like, maybe, they've been coming out in two groups and they've been maneuvering at x miles. Well, based on what they're doing, based on my ordinance, now if I merge, I'm going to my shot doctrine. When am I actually going to shoot this missile? Am I going to shoot it way far away? Am I going to shoot it closer? There's, I can't really go into too much more detail than that, but the bottom line is, what they're doing and what you're carrying, and how many missiles you have, and how long do you have to be there, is going to dictate your shot doctrine. When am I going to shoot these guys for the first time?